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Two new species of Pinwheel Snail from contrasting Queensland habitats and a redescription and generic re-assignment of *Gyrocochlea myora* Stanisic, 2010 (Gastropoda: Eupulmonata: Charopidae)

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ABSTRACT

Two new species of Charopidae are described from contrasting Queensland habitats. *Lithocouperia kalkajaka* gen. et sp. nov. lives among the granitic lithorefugia of Kalkajaka (=Black Mountain), Trevethen Range, NEQ. *Reticularopa minjerribah* gen. et sp. nov. chiefly inhabits the Blackbutt (*Eucalyptus pilularis*) and Scribbly Gum (*Eucalyptus racemosa*) sand-based, woodland communities of Minjerribah (=North Stradbroke Island), SEQ. A third species, '*Gyrocochlea*' *myora* Stanisic, 2010 known only from a small patch of rainforest along the Myora-Dunwich Road, Minjerribah, SEQ is redescribed and re-assigned to *Chordaropa* gen. nov. The use of protoconch microsculpture for determining generic units within the family is discussed. ❒ new genera, *new species, new combination, Gastropoda, Charopidae, Queensland.*

The Charopidae (Pinwheel Snails) is a family of tiny snails (mostly 1.5-5 mm shell diameter) of Gondwanan origin widely distributed on land masses in the Southern Hemisphere (Australia, New Zealand, South Africa and South America) and some Pacific islands. In Australia the family has its greatest diversity in the rainforests of eastern Australia (Queensland, New South Wales, Victoria and Tasmania); a very small number of species also exist in South Australia, Western Australia and the Red Centre (Smith 1992, Stanisic *et al.* 2010). The family was traditionally considered as being largely restricted to the temperate areas of south-eastern Australia. However, since 1980 large numbers of species have been collected from the subtropical and tropical regions of eastern Australia including approximately 80 species from the Wet Tropics Bioregion alone (Stanisic, pers. obs.). Most eastern Australian charopids have restricted distributions in wet forests and dry vine thickets with very few species having made the transition to the drier eucalypt forests where greatest diversity tends to be centered around isolated limestone habitats (Hyman & Stanisic 2005). Although there have been several major descriptive efforts at documenting new species since the late 1980's (Stanisic 1990, Hyman & Stanisic 2005, Stanisic *et al.* 2010, Shea *et al.* 2012) much of the Australian charopid fauna remains undescribed.

This study describes two new species of charopid from contrasting subtropical and tropical habitats in eastern Queensland and

FIG. 1. Granitic boulders and rainforest, Kalkajaka (=Black Mountain), north Queensland. Taken from Moulds & Olive (2014). Image: Fanie Venter.

redescribes and re-assigns one of the many '*Gyrocochlea*' species introduced by Stanisic *et al.* (2010). The three species included in this study are all allocated to new generic units within the family based on their novel patterns of protoconch sculpture. The species all fit the *Gyrocochlea* grade of shell organisation but differ dramatically in protoconch sculpture from that of true *Gyrocochlea* (type species: *Helix vinitincta* Cox, 1868) whose species are centred on the NSW/Qld Border (Stanisic 1990, Shea *et al.* 2012). They also differ in protoconch sculpture from the many patterns displayed by the other '*Gyrocochlea*-like' genera cited in Stanisic (1990), Hyman & Stanisic (2005) and Shea *et al.* (2012).

MATERIAL AND METHODS

Material used in this study is held in the mollusc collections of the Queensland Museum (QMMO). Measurements of shell height, diameter and umbilical width were made using Wild M5 stereo-microscope with a calibrated eyepiece. Only specimens with four whorls and above were measured. Whorl counts were made to the nearest 1/8 whorl. High resolution images of shells (260-600MB) were taken with a Visionary Digital BK-Plus lab system camera setup in the Queensland Museum's Digital Imaging Unit. Reproductive systems of all spirit specimens were examined but all were found to be immature.

Abbreviations used: NEQ, north-eastern Queensland; NSW, New South Wales; Qld, Queensland; RC, dry collection; SC, spirit collection; SEM, scanning electron microscopy; SEQ, south-eastern Queensland; SSE, south south-east; H/D, height ratio to diameter; D/U, diameter ratio to umbilical.

SYSTEMATICS

Infraorder EUPULMONATA

Superfamily PUNCTOIDEA

Family CHAROPIDAE

Genus *Lithocouperia* gen. nov.

Type species. *Lithocouperia kalkajaka* sp. nov.-herein designated.

Etymology. A contraction of lithorefugia, and for Patrick Couper who first introduced the former term into the literature.

Diagnosis. Shell small (large for family), light brown, discoidal with a strongly sunken spire; protoconch sculpture of numerous, closely spaced, spiral rows of tiny raised tubercles, teleoconch with moderately spaced protractively sinuate radial ribs, 40 on first adult whorl; microsculpture of numerous, closely spaced, fine radial threads crossed by equally fine spiral threads; aperture ovately lunate; umbilicus wide cup-shaped.

Lithocouperia kalkajaka sp. nov.
(Figs 2A-C, 6A, 7D, Table 1)

Etymology. Kalkajaka, the local indigenous name for Black Mountain, traditional home of the Kuku Nyungkul people.

Preferred common name. Kalkajaka Pinwheel Snail.

Material examined. Holotype. QMMO80719, Black Mtn, S of Cooktown, FNQ, 15°39'S,145°13'E, patchy

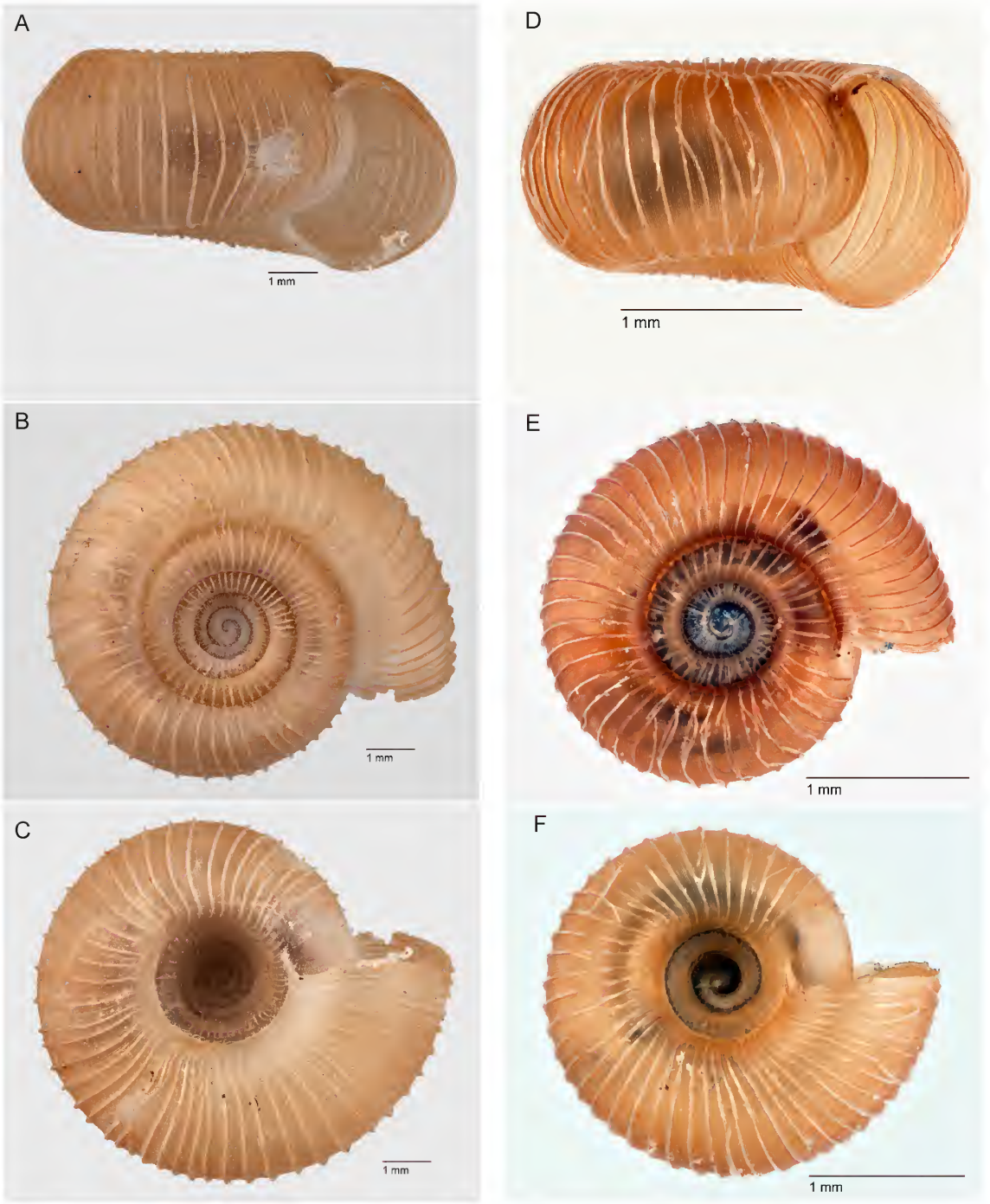

FIG. 2. **A-C**. *Lithocouperia kalkajaka* sp. nov., QMMO80719, holotype; **D-F**. *Reticularopa minjerribah* sp. nov., QMMO80720, holotype. Scale lines as marked.

FIG. 3. Scribbly Gum forest on sand, SE Dunwich, Minjerribah, SEQ.

vine thicket/granite boulders, 8.xi.1995, coll. G. Monteith, D. Cook, H. Janetzki, L. Roberts. Diameter of shell 8.75 mm, height 4.37 mm, umbilical width 2.83 mm, H/D 0.50, D/U 3.09, number of whorls 5.675.

Paratypes. (All subadult). QMMO78703, 2SC/1RC, same data as holotype.

Diagnosis. As for genus.

Description. Shell small, light brown, discoidal with a strongly sunken spire; whorls 5.675 tightly coiled, shouldered above and rounded below the periphery, last not descending in front; sutures strongly impressed. Height of shell 4.37 mm, diameter 8.75 mm, H/D 0.50. Protoconch flat, of 1.75 whorls sculptured with numerous crowded, spiral rows of tiny tubercles, teleoconch sculpture of moderately spaced protractively sinuate radial ribs, 40 on first adult whorl, 53 on body whorl. Microsculpture of numerous very fine radial riblets (35-40 between each pair of major ribs on body whorl) crossed by equally prominent and fine spiral threads. Aperture ovately lunate, lip simple. Umbilicus wide cup-shaped, diameter 2.83 mm, D/U 3.09. Based on one adult specimen (QMMO80719).

Reproductive anatomy unknown. All spirit specimens (QMMO78703) immature.

Habitat and ecology. Scattered patches of vine thicket with occasional *Ficus* sp.; living among granite boulders (Fig. 1).

Remarks. *Lithocouperia kalkajaka* sp. nov. is known only from the granite boulders (lithorefugia) of Kalkajaka (=Black Mountain), south of Cooktown, NEQ. It is the second largest Australian charopid recorded, eclipsed in size only by *Gyrocochlea vinitincta* (Cox 1868) from southern Queensland which has a recorded maximum diameter of 9.75 mm (Shea *et al.* 2012). The protoconch sculpture of *L. kalkajaka* is comparable with the finely cancellate sculpture seen on the protoconch of *Gyrocochlea* Hedley, 1924 from the Border Ranges of New South Wales–Queensland but differs most notably in having spiral rows of tiny tubercles without a radial component (Fig. 6A). This is a unique pattern among the Australian charopid protoconchs hitherto examined by SEM, including a number from the Wet Tropics Bioregion.

Reticularopa gen. nov.

Type species. *Reticularopa minjerribah* sp. nov.-herein designated.

Etymology. From the Latin *reticulata* = net, and a contraction of *Charopa*; referring to the net-like configuration of the protoconch sculpture.

Diagnosis. Shell tiny, brown, discoidal with a strongly sunken spire; protoconch sculpture of prominent widely spaced, sinuate radial ribs crossed by equally prominent and widely spaced spiral lirae and forming a distinct bead at their intersection, teleoconch with moderately spaced, protractively sinuate radial ribs, 39-48 on first adult whorl; microsculpture of fine radial riblets and low spiral cords; aperture ovately lunate; umbilicus wide cup-shaped.

Reticularopa minjerribah sp. nov.
(Figs 2D-F, 6C, 7E, Table 1)

Etymology. Minjerribah, the local indigenous name for North Stradbroke Island, traditional home of the Quandamooka people.

Preferred common name. Minjerribah Pinwheel Snail.

TABLE 1. Shell measurements of *Lithorefugia kalkajaka* sp. nov., *Reticularopa minjerribah* sp. nov. and *Chordaropa myora* Stanisic, 2010 comb. nov.

Taxon	N	Diameter (mm)	Height (mm)	Umbilical width (mm)	H/D ratio	D/U ratio	Number of whorls
L. kalkajaka sp. nov.							
QMMO80719 holotype	1	8.75	4.37	2.83	0.50	3.09	5.675
R. minjerribah sp. nov.							
QMMO80720 holotype	1	2.56	1.35	0.81	0.52	2.73	4
QMMO70511	4	2.34-2.50	1.25-1.31	0.88-0.94	0.52-0.54	2.33-2.79	4-4.125
QMMO70517	5	2.38-2.66	1.28-1.34	0.78-0.88	0.49-0.54	2.29-3.40	4-4.5
QMMO70442	2	2.46-2.56	1.25-1.34	0.84-0.88	0.51-0.53	2.93	4-4.25
QMMO70446	2	2.34-2.41	1.25	0.78	0.52-0.53	3.00-3.08	4-4.25
C. myora Stanisic, 2010							
QMMO20783 holotype	1	5.84	2.60	1.30	0.45	4.49	4.75
QMMO16819	2	4.09-4.54	2.14-2.27	1.30	0.50-0.52	3.15-3.49	4.25

Material examined. (All North Stradbroke Island, SEQ). Holotype. MO80720, SSE Dunwich, rainforest patch beside 18 Mile Swamp, 27°35′34″S, 153°27′50″E, in litter among bark, 5 m, coll. J Stanisic, D. Potter, 9.i.2002. Diameter of shell 2.56 mm, height 1.35 mm, umbilical width 0.81 mm, H/D 0.53, D/U 3.16, number of whorls 4.

Paratypes. QMMO70517, 35RC, same data as holotype; QMMO70442, 11RC, SSE Dunwich at Enterprise Mine Site, Scribbly Gum 2 Site, 27°36′48″S, 153°26′ 1″E, in litter among bark, 120 m, coll. J. Stanisic, D. Potter, 8.i.2002; QMMO70446, 1SC/7RC, SSE Dunwich at Enterprise Mine Site, Blackbutt 1 Site, 27°33′ 3″S, 153°27′34″E, in litter among bark, 90 m, coll. J. Stanisic, D. Potter, 8.i.2002; QMMO70511, 9RC, SSE Dunwich at Enterprise Mine Site, Blackbutt 3 Site, 27°34′33″S, 153°27′57″E, in litter among bark, 80 m, coll. J. Stanisic, D. Potter, 9.i.2002.

Other material. QMMO70438, 1RC, SSE Dunwich at Enterprise Mine Site, Mallee 1 Site, 27°34′27″S, 153°26′20″E, in litter among bark, 120 m, coll. J. Stanisic, D. Potter, 8.i.2002; QMMO70439, 4RC, SSE Dunwich at Enterprise Mine Site, Mallee 2 Site, 27°35′24″S, 153°26′35″E, in litter among bark, 100 m, coll. J. Stanisic, D. Potter, 8.i.2002; QMMO70440, 4RC, SSE Dunwich at Enterprise Mine Site, Mallee 3 Site, 27°35′49″S, 153°26′23″E, in litter among bark, 80 m, coll. J. Stanisic, D. Potter, 8.i.2002; QMMO70441, 6RC, SSE Dunwich at Enterprise Mine Site, Scribbly Gum 1 Site, 27°36′44″S, 153°26′27″E, in litter among bark, 70 m, coll. J. Stanisic, D. Potter, 8.i.2002; QMMO70443, 10SC/5RC, SSE Dunwich at Enterprise Mine Site, Scribbly Gum 3 Site, 27°35′35″S, 153°27′09″E, in litter among bark, 70 m coll. J. Stanisic, D. Potter, 8.i.2002; QMMO70447, 6RC, SSE Dunwich at Enterprise Mine Site, Blackbutt 2 Site, 27°33′37″S, 153°27′06″E, in litter among bark, 60 m, coll. J. Stanisic, D. Potter, 8.i.2002; QMMO70501, 1RC, SSE Dunwich at Enterprise Mine Site, Mallee 3 Site, open woodland, 27°35′49″S, 153°26′23″E, in litter, 80 m, C. Burwell, 8.i.2002; QMMO70502, 1RC, SSE Dunwich at Enterprise Mine Site, Blackbutt 1 Site, open woodland, 27°33′23″S, 153°27′34″E, in litter, 90 m, C. Burwell, 8.i.2002.

Diagnosis. As for genus.

Description. Shell tiny, discoidal, brown with a strongly sunken spire; whorls 4-4.5, tightly coiled, shouldered above and rounded below the periphery, last not descending in front; sutures strongly impressed. Diameter of shell 2.34-2.66 mm (mean 2.46 mm), height 1.25-1.35 mm (mean 1.29 mm), H/D 0.49-0.54 (mean 0.53 mm). Protoconch flat, of 1.5 whorls sculptured with prominent, widely spaced sinuate radial ribs crossed by equally prominent and widely spaced spiral lirae forming a distinct bead at their intersection, teleoconch sculpture of moderately spaced to crowded, protractively

sinuate radial ribs, 39-48 (mean 42) on first adult whorl, 50-96 (mean 69) on body whorl. Microsculpture of numerous very fine radial riblets, 15-20 between each pair of major ribs on body whorl, and low spiral cords. Aperture ovately lunate, lip simple. Umbilicus wide cup-shaped, diameter 0.78-0.94 mm (mean 0.85 mm), D/U 2.29-3.40 (mean 2.83). Based on 14 adult specimens (QMMO70442, 70446, 70511, 70517, 80720).

Reproductive anatomy unknown. All spirit specimens (QMMO70443, 70446) immature.

Habitat and ecology. Scribbly Gum and Blackbutt forest communities on sand; living among discarded bark and scattered timber (Fig. 3).

Remarks. *Reticularopa minjerribah* sp. nov. is only known from Minjerribah (=North Stradbroke Island), SEQ where it occurs widely in the woodland communities (Scribbly Gum, Blackbutt, Mallee) on sand. It is also found in a small patch of rainforest on sand at Eighteen Mile Swamp but not from the rainforest at Dunwich-Myora. This patch of forest is considered to have opportunistically developed on a patch of organically rich, humic sand on the edge of swampland. Protoconch features of *R. minjerribah* compare broadly with those of *Dictyoropa* Shea *et al.* 2012 (type species: *Gyrocochlea eurythma* Hedley, 1924) from the northern rivers area of NSW but differ in having the radial and spiral elements more defined and more widely spaced giving rise to a more open lattice network (Fig. 6C, D). The reticulate pattern of *R. minjerribah* is also present in several undescribed species from the adjacent mainland suggesting that this species may be part of a broader local radiation (Fig. 7C). The larger lots of specimens in the Queensland Museum include many with whorl counts less than four which is considered to constitute an immature shell (Stanisic 1990). Hence, the lack of measured specimens.

Chordaropa gen. nov.

Type species. *Gyrocochlea myora* Stanisic, 2010-herein designated.

Etymology. From the Greek *chorda* = cord, and a contraction of *Charopa*; referring to the low, broad, rope-like spiral cords on the protoconch.

Diagnosis. Shell tiny, light brown to beige, discoidal with a flat to slightly sunken spire; protoconch sculpture of low, broad spiral cords and weaker, curved radial ridges that become increasingly prominent toward the protoconch-teleoconch boundary, teleoconch with crowded, weakly protractively sinuate radial ribs, 90-110 on first adult whorl; microsculpture of fine radial riblets and low spiral cords; aperture ovately lunate; umbilicus wide U-shaped.

Remarks. *Chordaropa* gen. nov. differs from *Gyrocochlea* s.s. by having low, broad spiral cords and weak, curved radial ridges which contrast vividly with the distinctly fine, cancellate pattern seen in the latter. This difference is equivalent to the differences between *Gyrocochlea* s.s. and some of the new genera of Shea *et al.* (2012) and is herein considered sufficient to justify the introduction of a new genus for '*Gyrocochlea*' *myora* Stanisic, 2010.

Chordaropa myora Stanisic, 2010 comb. nov.
(Figs 5A-C, 6E, 7F, Table 1)

Gyrocochlea myora Stanisic 2010 (in Stanisic *et al.* 2010, sp. 286)

Preferred common name. Myora Pinwheel Snail.

Material examined. Holotype. QMMO20783, c. 2 km NE Dunwich on Dunwich-Myora road, North Stradbroke I., SEQ, 27°29'S,153°24'E, rainforest, in litter, coll. J. Stanisic, 23.iii.1989. Diameter of shell 5.84 mm, height 2.60 mm, umbilical width 1.30 mm, H/D 0.45, D/U 4.49, whorls 4.75.

Paratypes. QMMO78948, 2RC, same data as holotype; QMMO16819, 19RC/6SC, Myora, Stradbroke I., SEQ, rainforest, under logs, coll. J. Stanisic, 29.i.1984.

Diagnosis. As for genus.

Description. Shell tiny, discoidal with a flat to slightly sunken; whorls 4.25-4.75, tightly coiled, shouldered above and rounded below the periphery, last slowly descending in front; sutures strongly impressed. Diameter of shell

FIG. 4. Rainforest, Myora, Minjerribah, SEQ. Image: John Stanisic.

4.09–5.84 mm (mean 4.82 mm), height 2.14–2.60 mm (mean 2.34 mm), H/D 0.45–0.52 (mean 0.49). Protoconch flat, of 1.5 whorls sculptured with low, broad spiral cords and weaker, curved radial ridges that become increasingly prominent toward the protoconch-teleoconch boundary, teleoconch with very crowded, weakly protractively sinuate radial ribs, 90-110 on first adult whorl, 210-240 on body whorl. Microsculpture of numerous very fine radial riblets (approximately 10 between each pair of major ribs on body whorl) and low spiral cords. Aperture ovately lunate, lip simple. Umbilicus wide U-shaped, diameter 1.30 mm, D/U 3.15-4.49 (mean 3.71). Based on three adult specimens (QMMO16819, 20783).

Reproductive anatomy unknown. All spirit specimens (QMMO16819) immature.

Habitat and ecology. Rainforest; living under logs (Fig. 4).

Remarks. *Chordaropa myora* Stanisic, 2010 comb. nov. can be readily distinguished from the more widespread *R. minjerribah* by a combination of larger shell size, flat spire, more intense teleoconch ribbing and U-shaped rather than wide cup-shaped umbilicus. The species is found in the closed forest (= rainforest) community in the Dunwich-Myora area. The protoconch pattern in *C. myora* is broadly similar to that of *Diphyoropa* Hyman & Stanisic 2005 (type species: *Helix saturni* Cox, 1864) in that it is initially spiral with radial ribs becoming prominent on the latter half of the protoconch. However, the spiral elements of *C. myora* are more crowded and much less distinct than those of *Diphyoropa*. A similar protoconch pattern is present in '*Gyrocochlea*' *cinnamea* (Hedley, 1912) from Coolabunia, SEQ (Fig. 7A) and several other undescribed eastern Queensland charopids (Stanisic, unpubl.). The pattern in *Chordaropa* is somewhat similar to that of *Comboynea* Shea *et al.*, 2010 (type species: *Comboynea boorganna* Shea, Colgan & Stanisic, 2012) from mid-east NSW (Fig. 7B) which also has similar spiral cords on the protoconch but which lacks the curved radial ridges.

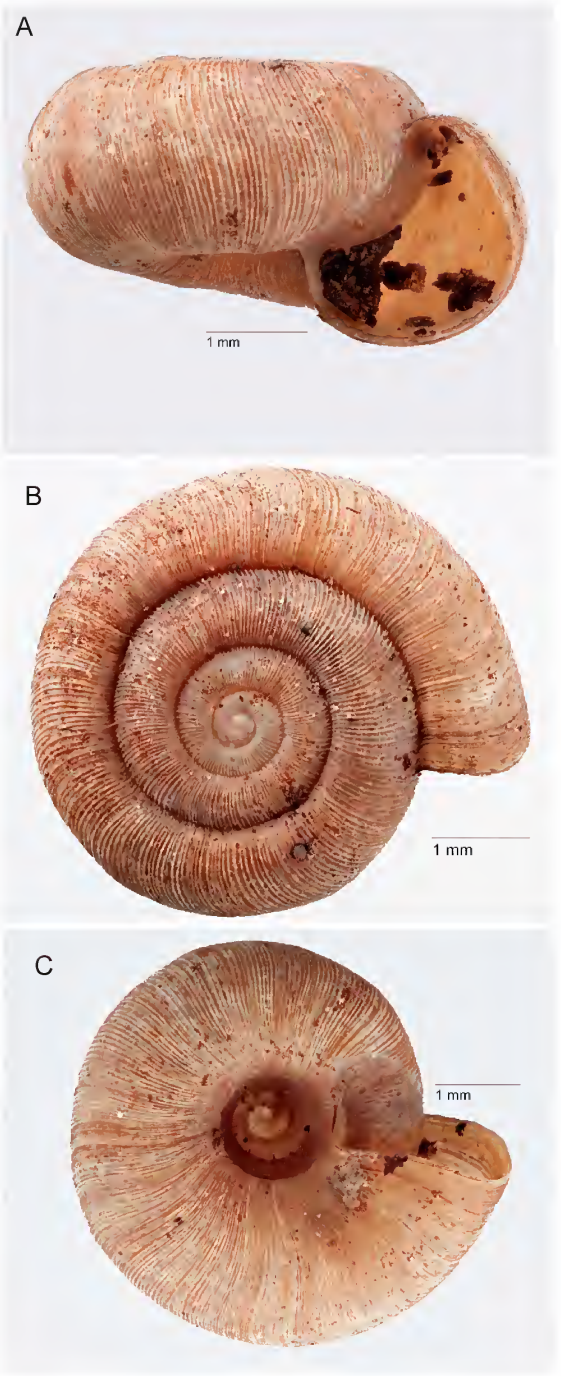

FIG. 5. **A-C.** *Chordaropa myora* (Stanisic, 2010) comb. nov., QMMO20783, holotype. Scale lines as marked.

GENERAL REMARKS

The description of two new species of Charopidae highlights two contrasting and unusual habitats for a family better known from rainforest and wet sclerophyll environments in eastern Australia (Stanisic *et al.* 2010). *Lithocouperia kalkajaka* sp. nov. lives among the granitic lithorefugia of Kalkajaka (=Black Mountain), Trevethen Range, NEQ. The Trevethen Range is located about 25 km south of Cooktown in the northern-most extension of the Einasleigh Uplands Bioregion and is also geographically adjacent to the Wet Tropic Bioregion. *Reticularopa minjerribah* sp. nov. chiefly inhabits the Blackbutt (*Eucalyptus pilularis*) and Scribbly Gum (*Eucalyptus racemosa*) sand-based, woodland communities of Minjerribah (= North Stradbroke Island), SEQ. A third species, '*Gyrocochlea*' *myora* Stanisic, 2010 known only from a small patch of rainforest at Myora-Dunwich Road, Minjerribah, SEQ is redescribed and re-assigned to *Chordaropa* gen. nov.

Lithocouperia kalkajaka sp. nov. displays a number of unusual features which distinguish it from other hitherto described charopids from the Einasleigh Uplands Bioregion and those from the northern reaches of the Wet Tropics Bioregion (Stanisic *et al.* 2010). The unusual architecture of the protoconch microsculpture (microtubercles) and the very large size (for the family) are a combination of shell features that also distinguish it from all other Queensland charopids. This species may be another endemic Kalkajaka invertebrate following on the recent description of the cicada *Tamasa caverna* Moulds & Olive, 2014. Charopids reach their northern limits in the Cooktown area and only one undescribed species is known from Cape York Peninsula (Stanisic, pers. obs.). The large numbers of undescribed species from the Wet Tropics may yet hold the key to origins of this most unusual charopid.

Reticularopa minjerribah sp. nov. and *Chordaropa myora* comb. nov. inhabit contrasting environments on Minjerribah and display contrasting shell morphologies. *R. minjerribah* from the sand-based woodland communities SSE

Dunwich has a depressed spire, strongly reticulate protoconch sculpture and moderately spaced ribs on the teleoconch. In contrast, *C. myora* from the small patch of rainforest in the Dunwich-Myora area has a flat spire, protoconch with rope-like broad spiral cords and very crowded ribbing on the teleoconch. The two species are endemic to the island but both appear to have congeners on the mainland (Stanisic, unpubl.). This is not surprising considering the relative proximity of the island to the mainland. However, many more mainland taxa will need to be studied before the origins of the two Minjerribah pinwheel snails can be determined.

DISCUSSION

In mainland eastern Australia (New South Wales and Queensland) 163 species of Charopidae have hitherto been documented (Stanisic *et al.* 2010). However there are over 350 unnamed putative species from this region in the Queensland Museum collections (Stanisic, pers. obs.). A further 69 species have been recorded from the rest of the continent but there are numerous species still to be described from the wet forests of Tasmania (Kevin Bonham, pers. comm.), Victoria (Stanisic pers. obs.) and Western Australia (Solem 1983). With less than half the known charopid fauna described, and with the many putative species in museum collections, the need for new species descriptions is compelling if only to begin the task of reducing the taxonomic backlog. However, species description requires generic assignment and that creates a problem for some groups when datasets consist solely of shells.

Generic classification of the Australian Charopidae

The three species dealt with herein are all considered to represent new genera based on their novel patterns of protoconch microsculpture. The fine architecture of this embryonic element of the charopid shell has been shown to be strongly indicative of generic differentiation within the family (Stanisic 1990, Hyman & Stanisic 2005, Shea *et al.* 2012).

Until recently, generic classifications in the family have been for the most part, less than informative. This has led to an unsatisfactory jumble of stand-alone, broadly defined, often polyphyletic generic units (e.g. Iredale 1937a, b). Historical classifications of the Charopidae are largely flawed by a shell-based morphology based on general shell form most often described as 'strongly ribbed, discoidal with an open umbilicus'. Without exception these approaches are characterised by a lack of attention to the many nuances of other shell characters such as protoconch and teleoconch microsculpture and coiling pattern (see Hedley 1924; Iredale 1937a,b, 1939, 1941; Smith & Kershaw 1979).

In particular, the microsculptural architecture of the protoconch in the Charopidae has, in the past, often been treated as a secondary character with descriptions of this feature limited to broad terms such as spiral, radial or cancellate/reticulate (a combination of both spiral and radial). Recent studies have shown that there are many, often subtle, variations on these broad themes that represent distinct generic-level differences between groups of species. These variations are not discernible with light microscopy even at the highest magnification and need to be interpreted with SEM which was not available to many former researchers.

Solem (1970) was the first land snail worker to formally introduce SEM to the study of the micro-architecture of tiny snails such as the Charopidae. One of Solem's first comments was to suggest that protoconch microsculpture could provide useful data for generic groupings within the tiny endodontoid land snails. Solem's (1976, 1983) classic monographs on the endodontid, punctid and charopid land snails of the Pacific Islands are illustrative of the informative detail one can extract from shell examination using SEM. These elaborate studies highlighted the significance of protoconch microsculpture in generic diagnosis. In the Australian sphere Smith & Kershaw (1985) were the first to exploit SEM for the description of three Tasmanian charopid genera. However, these authors provided only broad detail of the protoconch microsculpture with little accompanying illustration and

critical interpretation, e.g.'radially closely lirate, spirally lirate or decussate'…'radial and spiral lines'…'fine radial lines to smooth'.

Recent studies

Stanisic (1990) was the first major study of the Australian Charopidae using SEM to elucidate shell sculptural detail (in combination with anatomy) and the first to allude to a correlation between protoconch microsculpture and generic integrity. This study investigated the sculptural detail of 50 species of subtropical eastern Australian Charopidae and defined 18 genera on the basis of reproductive anatomy and detailed protoconch and teleoconch microsculpture. Hyman & Stanisic (2005), in a study that investigated 32 mainly limestone species in eastern NSW, found that protoconch microsculpture was critical in defining the 11 new genera of Charopidae introduced. More recently, the landmark study of Shea *et al.* (2012) used molecular analyses in addition to shell microsculpture and reproductive anatomy to propose a molecular-based phylogeny for a small cohort of '*Gyrocochlea*' species and their allies. Once again protoconch microsculpture was shown to be a key element in defining the eight new genera that were introduced. The overall conclusion from these studies indicates that it should be possible to confidently propose phylogenetically robust generic units based solely on features of protoconch microsculpture within the Australian Charopidae. This is a significant result for such a mega-diverse family that lives in the litter zone of moist forests and is usually collected as dead shells from litter sorting rather than as mature live individuals for anatomical and molecular studies. A fact highlighted in the current study where the datasets of spirit specimens and many dead shells were made up mainly of immature individuals and shells. The alternative is to keep overloading existing broad groupings, as is the case with *Gyrocochlea 'sensu* Stanisic *et al.* 2012', to the extent where currently over 100 species could easily be classified in this genus under the broad conchological umbrella of 'generally brown, radially ribbed, widely umbilicate shell' (Stanisic pers.obs.).

SEM vs. light microscopy interpretation of protoconch microsculpture

The protoconch of *Lithocouperia* gen. nov. when viewed under the light microscope (at 10 × 50 magnification) is very similar to that of *Gyrocochlea s.s.* in showing a 'frosted-glass' pattern. However, when viewed with SEM, the protoconch of *Lithocouperia* reveals a pattern of unconnected, spirally arranged tiny tubercles (Fig. 6A). This contrasts with the fine crowded spirals on the protoconch of *Gyrocochlea s.s* which when viewed by SEM shows a delicate cancellate pattern comprised of very crowded spiral lirae crossing numerous, very low, somewhat indistinct, fine radial ridglets forming elongate micro-beads at their intersection (Fig. 6B). The protoconch sculpture of *Reticularopa* gen. nov. when viewed with the light microscope resembles that of *Dictyoropa* Shea, Colgan & Stanisic, 2012 from the northern rivers region of north-eastern NSW in showing a reticulate pattern of radial ribs and spiral cords. However, with the assistance of SEM the reticulation of *Reticularopa* is shown to differ by having more widely spaced and more strongly defined radial ribs and spirals cords giving rise to a widely open lattice network (Fig. 6C) when compared with the diffuse low radial ridges and low spiral cords of *Dictyoropa* (Fig. 6D). The protoconch of *Chordaropa* gen. nov. when viewed with the light microscope exhibits a bimodal pattern similar to that of *Diphyoropa* Hyman & Stanisic, 2005 which has low, broad spiral cords initially and low, curved radial ridges that become more prominent toward the protoconch-teleoconch boundary. However, SEM reveals significant differences in the form of the spiral cords and radial ridges of the two genera. Those of *Chordaropa* are low, closely spaced spiral cords and low radial ridges (Fig. 6E) whereas those of *Diphyoropa* are relatively high and widely spaced (Fig. 6F). While at first sight some of these differences may seem points along a continuum and mere 'variations on a theme', each pattern of protoconch microsculpture described above has

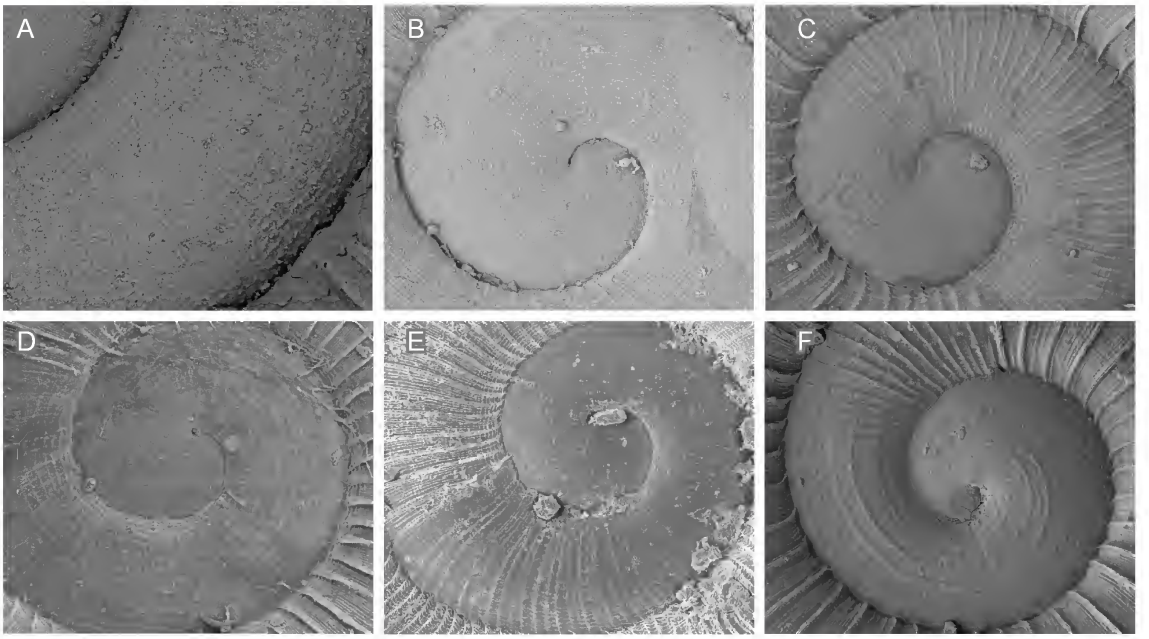

FIG. 6. Protoconch microsculpture. **A,** *Lithocouperia kalkajaka* sp. nov., QMMO78703, paratype; **B,** *Gyrocochlea vinitincta* (Cox 1868), AMSC.139752; **C,** *Reticularopa minjerribah* sp. nov., QMMO70517, paratype; **D,** *Dictyoropa eurythma* (Hedley 1924), AMSC103618, lectotype; **E,** *Chordaropa myora* (Stanisic, 2012) comb. nov., QMMO16819, paratype; **F,** *Diphyoropa saturni* (Cox 1864), AMSC318947.

in most cases, wider species representation in the landscape (geographic consistency) among both described and undescribed species (Shea *et al.* 2012, Stanisic unpubl.). This implies that each distinctive protoconch sculptural pattern essentially signifies a separate radiation of species (= genus).

While these examples clearly support the usefulness of protoconch microsculpture in defining charopid genera they also highlight the degree of difficulty in descriptively defining the various types. The development of a formal and unique set of descriptors for the various types of spiral, radial and reticulate sculptures seems a priority.

It is imperative that more charopids are described in order to make this group accessible to biogeography students and land managers. However, species descriptions must be accompanied by detailed SEM studies of protoconch sculpture, and proposed generic units clearly and formally defined so as to add to the informative phylogenetic frameworks proposed by Hyman & Stanisic (2005) and Shea *et al.* (2012). There will always be minor areas of contention when it comes to interpreting details of protoconch architecture for generic placement. Convergences, parallelisms and some conservatism in shell-based morphological characters will occasionally emerge to cloud interpretation. However, preliminary examination by the author of all currently recognised Australian charopid genera, indicate that these hurdles will be secondary to the sizeable and principal task of species documentation given the depth of the taxonomic impediment.

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The author wishes to acknowledge Geoff Thompson and Andy Wang of the Digital Imaging Unit, Queensland Museum for providing the high quality colour images of the three species studied herein. Thanks to Darryl Potter, Collection Manager, Queensland Museum for careful proof reading of the manuscript and to two independent reviewers for their constructive comments. All SEM images of *Reticularopa minjerribah*, *Chordaropa myora*, *Gyrocochlea vinitincta*, *Dictyoropa eurythma* and

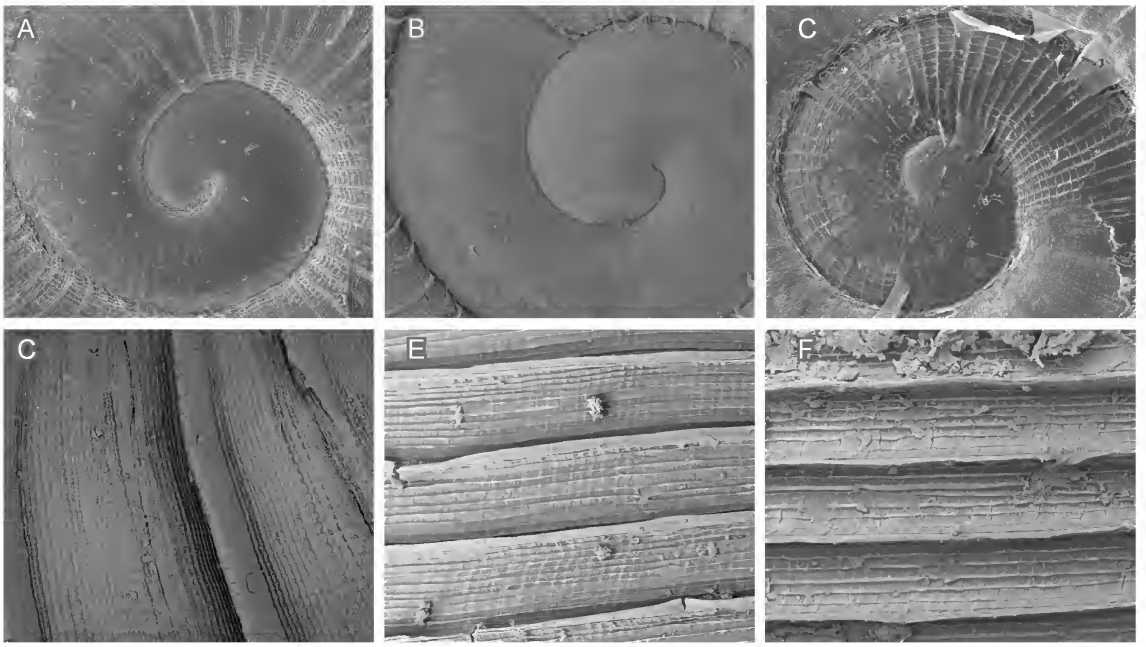

FIG. 7. A-C. Protoconch microsculpture. **A,** *'Gyrocochlea' cinnamea* (Hedley, 1912), AMSC154937; **B,** *Comboynea boorganna* Shea, Colgan & Stanisic, 2012, QMMO31451, paratype; **C,** Undescribed charopid, QMMO76839, Brisbane City. **D-F,** Teleoconch microsculpture. **D,** *Lithocouperia kalkajaka* sp. nov., QMMO78703, paratype ; **E,** *Reticularopa minjerribah* sp. nov., QMMO70517, paratype; **F**, *Chordaropa myora* Stanisic, 2010, QMMO16819

Dipyhoropa saturni are credited to Sue Lindsay, Australian Museum.

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New species of the genera *Amblytelus* Erichson, 1842 and *Dystrichothorax* Blackburn, 1892 from Queensland and New South Wales, Australia (Insecta: Coleoptera: Carabidae: Psydrini: Amblytelina)

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ABSTRACT

Five new species of the amblyteline genera *Amblytelus* Erichson, 1842 and *Dystrichothorax* Blackburn, 1892 are described from southern Queensland and northern New South Wales, Australia: *Amblytelus suturalis*, *Dystrichothorax trisetosus*, and *D. rufinus* from New England NP, northern New South Wales, and *D. wrightae* and *D. capitis* from localites in the Border Ranges about 100 km south-west of Brisbane, south-east Queensland. The species are introduced into the keys to the Australian species of the respective genera. ❐ *Coleoptera, Carabidae, Psydrini, Amblytelina, Amblytelus, Dystrichothorax, new species, Australia*

This is another supplement to the papers on the Australian amblyteline Psydrini (Baehr 2005, 2006a, 2006b, 2008), and the style and format of the descriptions exactly correspond to those in the revision (Baehr 2005). This paper also gives additional information about the Australian amblytelines, their morphology, distribution, and habits.

The psydrine subtribe Amblytelina is restricted to Australia and is notable for its arboricolous habits and its similar habitus and colouration to the arboricolous lebiine and cyclosomine genera *Agonocheila* Chaudoir, 1848, *Demetrida* White, 1846, *Philophlaeus* Chaudoir, 1844, *Trigonothops* Macleay, 1864, and *Sarothrocrepis* Chaudoir, 1850. The subtribe includes six genera of which *Amblytelus* Erichson, 1842 and *Dystrichothorax* Blackburn, 1892 are widely distributed and numerous in terms of species, whereas the four other genera include few or single species and possess restricted ranges.

The genus *Amblytelus* at present includes 47 taxa which are distributed through southern Australia including the Southwest and Tasmania, and along the east coast up to North Queensland. The genus *Dystrichothorax* includes 49 taxa which are distributed along the east coast of Australia from Tasmania and southern Victoria to North Queensland, where several species occur on Atherton, Carbine, and Windsor Tablelands, respectively, but not further north.

The species of both genera live on tree trunks, either under bark of bark-shedding eucalypts in dry sclerophyll forests and woodland, or on (moss covered) tree trunks in wet sclerophyll forest and rain forest. In particular the rain forest inhabiting species apparently possess quite restricted ranges on single or few mountain

tops or tablelands, many of these species are rare in collections. This may be due either to their actual restricted ranges, or to inadequate sampling efforts. Rain forest dwelling species are best collected by pyrethrum fogging which has been comprehensive only in a few areas, and limited in others.

Workers of Queensland Museum, however, are reknowned for this collecting method. Consequently, they repeatedly detect additional species, as well as improving our knowledge of distribution and ecology of this beetle group. A sample of Australian Psydrini sent from the Queensland Museum, Brisbane, contained not only some rare described species, but also five new species which are described in this paper.

METHODS

For the taxonomic treatment, standard methods were used. The genitalia were removed from specimens relaxed for a night in a jar under moist atmosphere, then cleaned for a short while in hot 10% KOH. The habitus photographs were taken with a digital camera using ProgRes CapturePro 2.6 and AutoMontage and subsequently edited with Corel Photo Paint X4.

Measurements were taken using a stereo microscope with an ocular micrometer. Length has been measured from the apex of the labrum to the apex of the elytra. Length of pronotum was measured along midline. Length of elytra was taken from the most advanced part of the humerus to the most advanced part of the apex.

The holotypes are stored at the Queensland Museum, Brisbane (QM), a few paratypes are deposited in the working collection of the author in the Zoologische Staatssammlung, München (CBM). Label data of specimens are given verbatim, including all ciphers and printed labels. Also original spelling of the collecting date is used.

Abbreviations. ab, ambulatory setae on male and female terminal abdominal sternite; el, fixed setae on 3rd, 5th, and 7th elytral intervals; pr, anterior and posterior marginal setae on pronotum; CBM, working collection M. Baehr in Zoologische Staatssammlung, München; QM, Queensland Museum, Brisbane; NSW, New South Wales; QLD, Queensland; >, larger or longer than; <, smaller or shorter than.

Genus *Amblytelus* Erichson, 1842

Erichson. 1842: 129. – Baehr 2005: 26.

Type species. *Carabus curtus* Fabricius, 1801, by monotypy.

Diagnosis. Characterised within the subtribe Amblytelini by deeply cleft and densely squamose 4th tarsomeres and presence of two marginal setae on the pronotum. Within the genus external structure, e.g. body shape, chaetotaxy, colouration and elytral colour pattern, and structure of the male genitalia are remarkably variable, which justify the distinction of several rather well defined species-groups.

Note. The genus occurs in the southern part of Western Australia, southern South Australia, Victoria, Tasmania, Australian Capital Territory, eastern New South Wales, and eastern Queensland. At present the genus includes 43 species and 4 additional subspecies.

Amblytelus suturalis sp. nov.
(Figs 1, 6)

Material. HOLOTYPE: ♂, NSW: 30.492°Sx152.406°E New England NP, Banksia Pt, 1480 m, 14 Jun 2009 G.Monteith & F.Turco. Pyrethrum Knockdown. Nothofagus forest 17476' (QMT 234154). Paratype: ♀, NSW: 30°29'42''S, 152°21'27'' Point Lookout Rd, radar beacon, 1390 m, 13-14 Nov 2008. G.Monteith. Pyrethrum, trees, open forest. (CBM).

Etymology. The name refers to the distinct sutural stripe on the elytra.

Diagnosis. Medium-sized species of the *discoidalis*-group in the sense of Baehr (2005), with distinct, triangular, pale sutural stripe; distinguished from the most similarly patterned *A. marginicollis* Sloane, 1911 by decidedly less explanate lateral margins of the pronotum and longer aedeagus; and from two species with similarly elongate aedeagus (*A. matthewsi* Baehr, 2005 and *A. weiri* Baehr, 2005) by different elytral pattern.

FIGS 1-5. Habitus. Body lengths in brackets. **1.** *Amblytelus suturalis* sp. nov. (6.2 mm). **2.** *Dystrichothorax wrightae* sp. nov. (7.1 mm). **3.** *Dystrichothorax capitis* sp. nov. (7.8 mm). **4.** *Dystrichothorax rufinus* sp. nov. (6.6 mm). **5.** *Dystrichothorax trisetosus* sp. nov. (5.6 mm).

Description. *Measurements.* Length: 5.9-6.2 mm; width: 2.5-2.6 mm. Ratios. Length eye/orbit: 5.7; width/length of pronotum: 1.48-1.52; width base/apex of pronotum: 1.46-1.52; width pronotum/head: 1.33-1.35; length/width of elytra: 1.68; width elytra/pronotum: 1.56.

Colour (Fig. 1). Head and pronotum rufous; elytra almost black, with distinct, triangular, red sutural spot and red lateral margin that includes the 8th interval. Palpi yellow, antenna red with paler 1st antennomere. Femora yellow, tibiae and tarsi slightly darker. Lower surface pale red.

Chaetotaxy. pr: 1, 1; el: 0, 0, 0; ab: 2, 6.

Head (Fig. 1). Of average size, considerably narrower than pronotum, frons in middle convex. Eye very large, laterally markedly protruded. Orbit very short, < 1/5 of length of eye, very oblique, evenly merging into curvature of eye, forming a distinct angle with neck. Labrum anteriorly slightly sinuate. Mandibles short and wide. Submentum unisetose on either side. Tooth of mentum large, wide, rather acute. Glossa apically straight, bisetose, paraglossae hyaline, slightly surpassing glossa. Lacinia with a few strong spines. Both palpi rather short, obliquely cut at apex, impilose. Antenna fairly elongate, surpassing base of pronotum by almost two antennomeres. Median antennomeres c. 2 x as long as wide. Posterior supraorbital seta slightly removed from eye, situated at posterior margin of eye. Frontal furrows rather elongate, deep, rather linear, sinuate. Frons without any impression in middle. Surface impunctate, without microreticulation, very glossy.

Pronotum (Fig. 1). Rather wide, with wide base, disk rather convex, widest diameter about at middle. Apex with very shallow, straight excision, apical angle little protruded, widely rounded. Lateral margin evenly convex, very slightly concave just in front of the basal angle, incurved to apex. Basal angle rectangular, laterally slightly produced. Base in middle convex, slightly sinuate on either side. Apex in middle not margined, base coarsely margined. Marginal channel moderately wide, explanate, slightly widened towards base, margin upturned. Median line distinct but feebly impressed, neither reaching apex nor base. Both, anterior and posterior transversal sulci shallow. Basal grooves linear, slightly oblique, deep, separated from marginal channel. Anterior marginal seta situated slightly in front of middle, at the inner margin of the marginal sulcus. Posterior marginal seta arising at lateral margin on basal angle. Surface impunctate, without microreticulation, very glossy.

Elytra (Fig. 1). Rather elongate, almost parallel sided, barely widened posteriad, disk rather depressed. Humerus angulate, slightly protruded, basal margin gently angulate. Lateral margin at apex convex. Lateral apical fold very strong. All striae complete, though 7th stria weak. Striae impressed, finely crenulate, only 7th stria consisting of a row of punctures; intervals gently convex. Disk without setiferous punctures. Marginal channel with 14 setiferous punctures, series slightly interrupted behind middle, punctures fine. Two additional setiferous punctures located near apex at the ends of striae 2 and 3. Intervals impunctate, with extremely fine, very superficial microreticulation consisting of markedly transverse meshes. Surface very glossy.

Posterior wings. Fully developed.

Lower surface. Metepisternum rather elongate, c. 2.5 x as long as wide at apex.

Male genitalia (Fig. 6). Genital ring asymmetric, with rather narrow apex and angulate, produced lateral angle. Aedeagus elongate, comparatively narrow, depressed, gently sinuate, apex curved slightly to right. Lower surface gently bisinuate. Apex comparatively narrow (in group), very obtuse, evenly curved, about spoon-shaped, slightly turned down at tip. Tip widely sclerotized. Internal sac with some elongate, sclerotized plates at base. Both parameres elongate, with narrow, very elongate apex, with a single, fairly elongate apical seta. Right paramere with one additional short seta at upper margin near apex, left paramere without any additional setae. Left paramere larger and at base wider than right, right paramere very narrow.

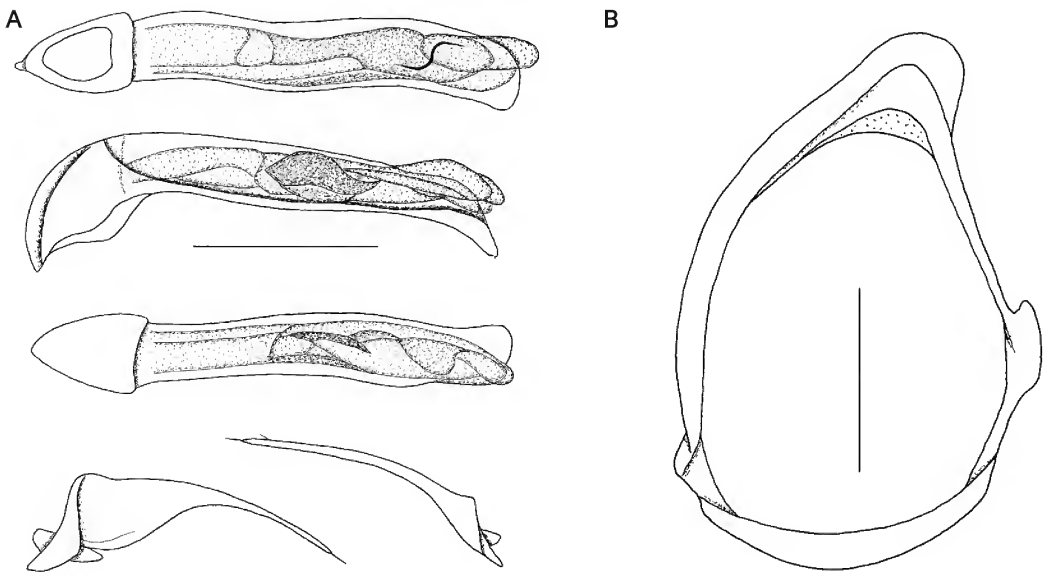

FIG. 6. A-B, *Amblytelus suturalis* sp. nov. **A**, male genitalia; **B**, genital ring

Female gonocoxites. Very similar to those in figs 133-135 in Baehr (2005), but gonocoxite 2 with 3 latero-ventral ensiform setae.

Variation. Apart from some differences in shape of pronotum very little variation noted.

Distribution. New England Tableland, north-eastern New South Wales, Australia.

Collecting circumstances. Both specimens were collected by pyrethrum spraying at high altitude, the holotype in *Nothofagus* forest, the paratype in open forest.

Relationships. With respect to shape of aedeagus most similar to *A. weiri* Baehr, 2005 from Barrington Tops, but the elytral pattern is very similar to that of the sympatric *A. marginicollis* Sloane, 1911.

Genus *Dystrichothorax* Blackburn, 1892

Blackburn, 1892: 86, 88. – Baehr 2005: 128.

Type species. *Amblytelus amplipennis* Macleay, 1871, by original designation.

Diagnosis. Characterised within the subtribe Amblytelini by deeply cleft and densely squamose 4th tarsomeres and absence of the anterior marginal seta of the pronotum. External structure, e.g. body shape, chaetotaxy, colouration and elytral colour pattern, and structure of the male genitalia are moderately different within the genus, which justify the distinction of several rather well defined species-groups.

Note. The genus occurs in eastern Victoria, Tasmania, Australian Capital Territory, eastern New South Wales, and eastern Queensland. At present the genus includes 46 species and additional 3 subspecies.

Dystrichothorax wrightae sp. nov.
(Figs 2, 7)

Material. HOLOTYPE: ♂, QLD: 28.234°Sx152.483°E 'The Head' gate, 820 m 29 Mar 2014. G.Monteith Barkspray, rainfor25495 (QMT 234158). PARATYPES: 1 ♂, 1 ♀, same data (CBM, QM); 2 ♂♂, NSW: 28°29'Sx152°24'E Tooloom Scrub, 720 m 16-17 Aug 2005, 52480 C.Burwell, S.Wright rainforest, pyrethrum (CBM, QM).

Etymology. The name is a patronym in honour of one of the collectors, Susan Wright of Queensland Museum.

Diagnosis. Medium-sized, uniformly rufous species of the *lividus*-group in the sense of Baehr (2005), with comparatively large eye, and with a densely denticulate, triangular fold in the apical part of the internal sac of the aedeagus; distinguished from the very similar *D. catrionae* Baehr, 2005 by narrower, laterally more straight pronotum, slightly longer elytra, more laterad curved, shorter apex of the aedeagus, and different arrangement of the denticulate fold in the internal sac; and from the externally very similar *D. parallelocollis* Baehr, 2005, by presence of the mentioned triangular, denticulate fold.

Description. *Measurements.* Length: 6.7-7.3 mm; width: 2.65-2.95 mm. Ratios. Length eye/orbit: 3.6-3.8; width/length of pronotum: 1.22-1.27; width base/apex of pronotum: 1.54-1.58; width pronotum/head: 1.21-1.25; length/width of elytra: 1.68-1.74; width elytra/pronotum: 1.78-1.83.

Colour (Fig. 2). Reddish-piceous to piceous; pronotum and elytra with narrow, yellow margins. Palpi and antenna more or less pale red, 1st antennomere slightly paler. Femora dark yellow to pale red, tibiae and tarsi slightly darker. Lower surface pale red.

Chaetotaxy. pr: 0, 1; el: 2, 0, 0; ab: 4, 8.

Head (Fig. 2). Rather large, little narrower than pronotum, frons in middle convex. Eye large, laterally well protruded. Orbit short, slightly > 1/4 of length of eye, oblique, evenly merging into curvature of eye, forming a distinct angle with neck. Labrum anteriorly straight. Mandibles short and wide. Submentum bisetose on either side. Tooth of mentum large, wide, rather acute. Glossa apically straight, bisetose, paraglossae hyaline, slightly surpassing glossa. Lacinia with a few strong spines. Both palpi rather short, obliquely cut at apex, impilose. Antenna elongate, surpassing base of pronotum by almost three antennomeres. Median antennomeres > 2.5 x as long as wide. Posterior supraorbital seta slightly removed from eye, situated at posterior margin of eye. Frontal furrows rather elongate, deep, linear, slightly oblique and sinuate. Frons without any distinct impression in middle. Surface impunctate, without microreticulation, very glossy.

Pronotum (Fig. 2). Narrow, rather quadrate with wide base, disk rather convex, widest diameter at base, or base at least barely narrower than at middle. Apex with very shallow, straight excision, apical angle little protruded, widely rounded. Lateral margin in basal half straight or almost so, extremely slightly concave just in front of the basal angle, incurved to apex. Basal angle rectangular, laterally feebly produced. Base in middle convex, laterally slightly sinuate. Apex not margined, base coarsely margined. Marginal channel rather narrow, deep, slightly widened towards base, margin upturned. Median line distinct and slightly impressed, almost reaching apex and base. Both anterior and posterior transversal sulci very shallow. Basal grooves linear, almost straight, deep, separated from marginal channel. Posterior lateral seta arising at lateral margin on basal angle. Surface with very fine transverse strioles, impunctate, without microreticulation, very glossy.

Elytra (Fig. 2). Rather elongate, gently oval shaped, slightly widened posteriad, disk moderately convex. Humerus angulate, slightly protruded, basal margin gently angulate. Lateral margin at apex convex. Lateral apical fold strong. Six median striae present, 7th stria barely perceptible or absent. Striae slightly impressed but less so in basal half, finely, more or less perceptibly punctulate. Intervals in basal half rather depressed, in apical half gently convex. Disk with two setiferous punctures, both situated at the median side of 3rd stria; the anterior puncture located at or slightly in front of middle, the posterior about at basal fifth or sixth. Marginal channel with 13-14 setiferous punctures, series slightly interrupted behind middle, punctures fine. Two additional setiferous punctures located near apex at the ends of striae 2 and 3. Intervals impunctate, with fine, superficial microreticulation consisting of transverse meshes. Surface rather glossy.

Posterior wings. Fully developed.

Lower surface. Metepisternum elongate, slightly > 2 x as long as wide at apex.

Male genitalia (Fig. 7). Genital ring wide, asymmetric, with asymmetric, wide, oblique

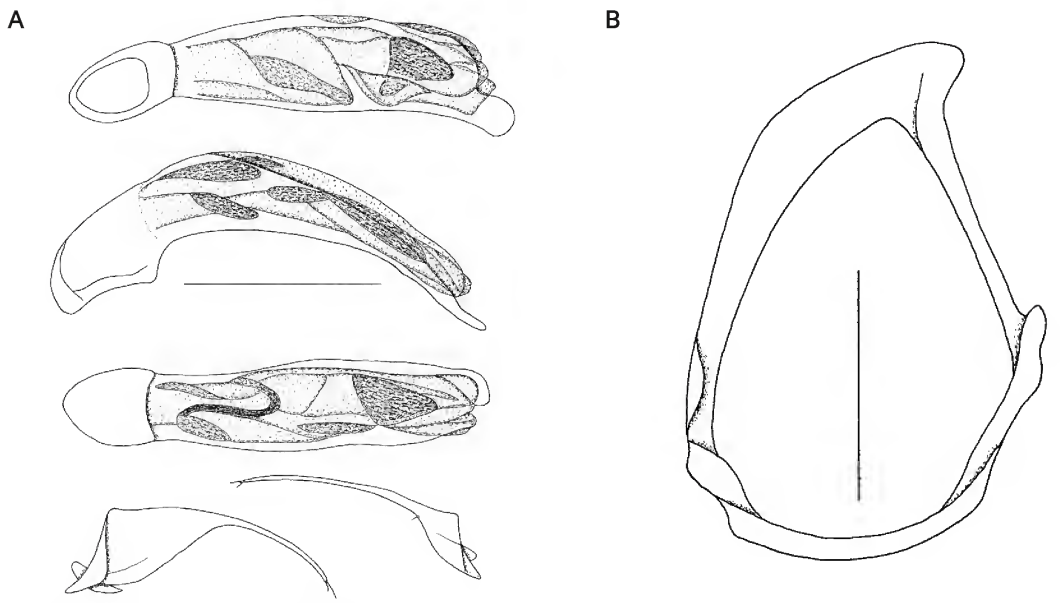

FIG. 7. A-B, *Dystrichothorax wrightae* sp. nov. **A**, male genitalia; **B**, genital ring

apex and angulate, produced lateral angle. Aedeagus moderately elongate, slightly widened in middle and slightly sinuate, apex situated on the right side, slightly turned right, though tip markedly curved left. Lower surface basally straight, in apical third gently concave. Apex short (in group), wide, widely rounded at tip, very asymmetric. Tip sclerotized. Internal sac with sme elongate sclerotized plates in basal part, and with a characteristic, multidenticulate, sclerotized plate at bottom near apex. Both parameres very elongate, with narrow and elongate apex. Right paramere with 2 short apical setae, and with a single, very short seta in middle of lower margin. Left paramere larger and at base much wider than right, apex barely curved, with 2 short apical setae, without additional setae.

Female genitalia. Very similar to those in figs 136-146 in Baehr (2005).

Variation. Apart from minor differences in shape of pronotum, length of elytra, and depth and punctation of the elytral striae very little variation noted

Distribution. The Border Ranges between Queensland and New South Wales.

Collecting circumstances. Sampled by 'barkspray' in upland rain forest.

Relationships. According to external morphology and to shape and structure of the male aedeagus, this species is closely related to *D. catrionae* Baehr, 2005 from Acacia Creek in north-eastern NSW and *D. parallelocollis* Baehr, 2005 from Conondale Range, Mt Tamborine, and Bunya Mts in south-eastern Queensland.

Dystrichothorax capitis sp. nov.
(Figs 3, 8)

Material. HOLOTYPE: ♂, QLD: 28.298°Sx 152.430°E Plateau south of 'The Head', 1035 m, 29 Mar 2014, G.Monteith, Barkspray, rainfor25494 (QMT 234155). PARATYPES: 1 ♂, 2 ♀♀, same data (CBM, QM).

Etymology. The name refers to the type locality 'The Head' in south-eastern Queensland.

Diagnosis. Fairly large, piceous species of the *australis*-group in the sense of Baehr (2005), with moderately large eye and an elongate, conspicuously denticulate fold in the apical

part of the internal sac of the aedeagus; distinguished from the very similar *D. difficilis* Baehr, 2005 by the head being slightly paler than pronotum and elytra, and by presence of the mentioned denticulate fold.

Description. *Measurements.* Length: 7.7-7.9 mm; width: 3.1-3.2 mm. Ratios. Length eye/orbit: 2.1-2.25; width/length of pronotum: 1.27-1.28; width base/apex of pronotum: 1.52-1.62; width pronotum/head: 1.26-1.28; length/width of elytra: 1.65-1.67; width elytra/pronotum: 1.76-1.84.

Colour (Fig. 3). Head rufous, pronotum and elytra reddish-piceous to piceous, lateral margins of pronotum and elytra narrowly pale translucent; palpi and basal antennomeres more or less pale red, antenna apicad slightly darker. Legs piceous, but apex of tibiae, and tarsi paler.

Chaetotaxy. pr: 0, 1; el: 2, 0, 0; ab: 4, 8.

Head (Fig. 3). Rather large, little narrower than pronotum, frons in middle convex. Eye rather large, laterally moderately protruded. Orbit elongate, > half of length of eye, oblique, evenly merging into curvature of eye, forming a fairly distinct angle with neck. Labrum anteriorly straight. Mandibles short and wide. Submentum unisetose on either side. Tooth of mentum large, wide, rather acute. Glossa apically straight, bisetose, paraglossae hyaline, slightly surpassing glossa. Lacinia with a few strong spines. Both palpi fairly elongate, obliquely cut at apex, impilose. Antenna elongate, surpassing base of pronotum by at least three antennomeres. Median antennomeres almost 3 x as long as wide. Posterior supraorbital seta slightly removed from eye, situated well behind posterior margin of eye. Frontal furrows rather elongate, moderately deep, linear, slightly oblique and sinuate. Frons without any distinct impression in middle. Surface impunctate, without microreticulation, very glossy.

Pronotum (Fig. 3). Narrow, rather quadrate with wide base, disk rather convex, widest diameter at base, or base at least barely narrower than at middle. Apex with very shallow, straight excision, apical angle little protruded, widely rounded. Lateral margin in basal half straight or almost so, extremely slightly concave just in front of the basal angle, incurved to apex. Basal angle rectangular, laterally feebly produced. Base in middle convex, laterally oblique and slightly sinuate. Apex not margined, base coarsely margined. Marginal channel rather narrow, deep, slightly widened towards base, margin upturned. Median line distinct and slightly impressed, almost reaching apex and base. Both anterior and posterior transversal sulci very shallow. Basal grooves linear, almost straight, deep, separated from marginal channel. Posterior lateral seta arising at lateral margin on basal angle. Surface with very fine transverse strioles, with very sparse and extremely fine punctures, without microreticulation, very glossy.

Elytra (Fig. 3). Rather elongate, gently oval shaped, slightly widened posteriad, disk moderately convex. Humerus angulate, slightly protruded, basal margin gently angulate. Lateral margin at apex convex. Lateral apical fold strong. Six median striae present, 7th stria less distinct and only indicated by a row of punctures. Striae well impressed but slightly less so in basal half, finely, punctulate; intervals in basal half gently convex, in apical half convex. Disk with two setiferous punctures, both situated at the median side of 3rd stria; the anterior puncture located slightly in front of middle, the posterior about at basal fifth or sixth. Marginal channel with 13-14 setiferous punctures, series slightly interrupted behind middle, punctures fine. Two additional setiferous punctures located near apex at the ends of striae 2 and 3. Intervals impunctate, with fine, distinct microreticulation consisting of slightly transverse meshes. Surface moderately glossy.

Posterior wings. Fully developed.

Lower surface. Metepisternum elongate, slightly > 2 x as long as wide at apex.

Male genitalia (Fig. 8). Genital ring wide, asymmetric, with asymmetric, rather wide, oblique apex and angulate, produced lateral angle. Aedeagus elongate, barely widened in middle, slightly sinuate, apex situated on the right side, slightly turned right. Lower surface in basal half concave, in apical half almost straight.

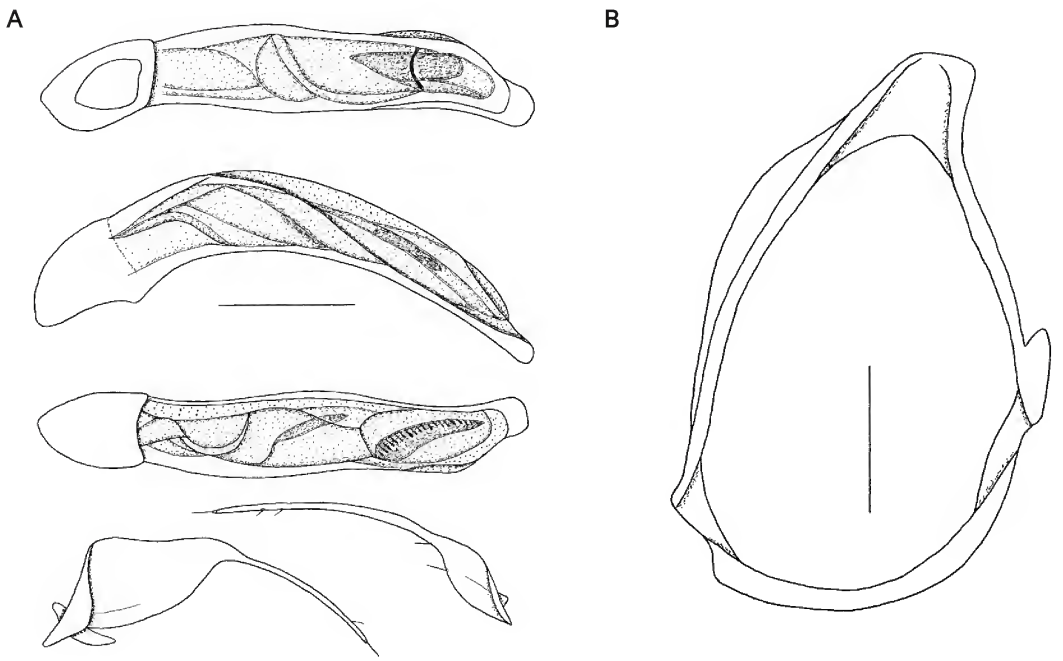

FIG. 8. A-B, *Dystrichothorax capitis* sp. nov. **A**, male genitalia; **B**, genital ring

Apex rather short, wide, somewhat spatulate, rounded at tip. Tip sclerotized. Internal sac with some elongate, gently sclerotized folds in basal part, and with a characteristic, elongate, multidentate, sclerotized plate at roof near apex. Both parameres very elongate, with narrow and elongate apex. Right paramere with 1 short apical seta, and with two short setae each on lower margin near apex and at base. Left paramere larger and at base much wider than right, apex barely curved, with 1 short apical seta, and a single, short seta on upper margin near apex.

Female genitalia. Very similar to those in figs 136-146 in Baehr (2005).

Variation. Apart from minor differences in shape of pronotum very little variation noted

Distribution. On the NSW/Qld Border Ranges, 100 km SW of Brisbane, Australia. Known only from the type locality.

Collecting circumstances. Sampled by 'barkspray in rainforest' at high altitude.

Relationships. According to external morphology and to shape of the aedeagus, this species is most similar and probably also closely related to *D. difficilis* Baehr, 2005 from Lamington NP in south-east Queensland and Dorrigo and Acacia Creek in north-eastern New South Wales.

Dystrichothorax rufinus sp. nov.
(Fig. 4)

Material. HOLOTYPE: ♀, 'NSW:30.492°Sx152.406°E New England NP, Banksia Pt, 1480 m, 14 June 2009 G.Monteith & F.Turco. Pyrethrum knockdown. Nothofagus forest 17476' (QMT 234156).

Etymology. The name refers to the red surface.

Diagnosis. Medium-sized, uniformly pale red species of the *lividus*-group in the sense of Baehr (2005) with large, well protruded eye; distinguished from all other species of this group, except *D. demarzi* Baehr, 2005 and *D. lewisensis* Baehr, 2005 from North Queensland, by unipunctate elytra. Distinguished from these

species by paler colouration and decidedly wider pronotum.

Description. *Measurements.* Length: 6.6 mm; width: 3.0 mm. Ratios. Length eye/orbit: 3.8; width/length of pronotum: 1.36; width base/apex of pronotum: 1.5; width pronotum/head: 1.30; length/width of elytra: 1.55; width elytra/pronotum: 1.97.

Colour (Fig. 4). Surface, including mouth parts, antennae, and legs uniformly pale red.

Chaetotaxy. pr: 0, 1; el: 1, 0, 0; ab: ?, 8.

Head (Fig. 4). Rather large, but considerably narrower than pronotum, frons in middle convex. Eye large, laterally markedly protruded. Orbit short, c. 1/5 of length of eye, oblique, evenly merging into curvature of eye, forming a fairly distinct angle with neck. Labrum anteriorly slightly concave. Mandibles short and wide. Submentum bisetose on either side. Tooth of mentum large, wide, rather acute. Glossa apically straight, bisetose, paraglossae hyaline, slightly surpassing glossa. Lacinia with a few strong spines. Both palpi fairly elongate, obliquely cut at apex, impilose. Antenna elongate, surpassing base of pronotum by slightly > 2 antennomeres. Median antennomeres c. 2.5 x as long as wide. Posterior supraorbital seta slightly removed from eye, situated at posterior margin of eye. Frontal furrows rather elongate, moderately deep, linear, slightly oblique and sinuate. Frons without any distinct impression in middle. Surface impunctate, without microreticulation, very glossy.

Pronotum (Fig. 4). Moderately narrow, considerably wider than long, with wide base, disk rather convex, widest diameter in middle, but base barely narrower than at middle. Apex with very shallow, straight excision, apical angle little protruded, widely rounded. Lateral margin gently convex throughout, more so in apical half, not concave in front of the basal angle. Basal angle rectangular, laterally not produced. Base in middle convex, laterally oblique and slightly sinuate. Apex not margined, base coarsely margined. Marginal channel rather narrow, deep, slightly widened towards base, margin upturned. Median line distinct and slightly impressed, almost reaching apex and base. Both anterior and posterior transversal sulci very shallow. Basal grooves linear, almost straight, deep, separated from marginal channel. Posterior lateral seta arising at lateral margin on basal angle. Surface with very fine transverse strioles, impunctate, without microreticulation, very glossy.

Elytra (Fig. 4). Rather elongate, gently oval shaped, slightly widened posteriad, disk moderately convex. Humerus angulate, slightly protruded, basal margin gently angulate. Lateral margin at apex convex. Lateral apical fold strong. Seven striae indicated but only in apical half perceptibly impressed, 7th stria less distinct and only indicated by a row of punctures. Striae barely punctulate; intervals only in apical half gently convex. Disk with one setiferous puncture, situated at apical quarter and at the median side of the 3rd stria. Marginal channel with 12-14 setiferous punctures, series slightly interrupted behind middle, punc tures fine. One additional setiferous puncture located near apex at the end of the 3rd stria. Intervals impunctate, with fine, rather superficial microreticulation consisting of slightly transverse meshes. Surface glossy.

Posterior wings. Fully developed.

Lower surface. Metepisternum elongate, slightly > 2 x as long as wide at apex.

Male genitalia. Unknown.

Female genitalia. Very similar to those in figs 136-146 in Baehr (2005).

Variation. Unknown.

Distribution. New England Tableland, north-eastern New South Wales, Australia. Known only from type locality.

Collecting circumstances. Sampled by 'pyrethrum knockdown in *Nothofagus* forest' at high altitude.

Relationships. In view of the yet unknown male genitalia the relationships are unsettled. However, in its large eyes and the unipunctate elytra the species differs from all species of the

lividus-group that occur in New South Wales and south Queensland.

Dystrichothorax trisetosus sp. nov.
(Figs 5, 9)

Material. HOLOTYPE: ♀, NSW: 30°29'42''S, 152°21'27'' Point Lookout Rd, radar beacon, 1390 m, 13-14 Nov 2008. G.Monteith. Pyrethrum, trees, open forest. (QMT 234157).

Etymology. The name refers to the presence of three setiferous punctures on the apical part of the 7th interval of the elytra.

Diagnosis. Medium-sized, uniformly rufous species of the *placidus*-group in the sense of Baehr (2005) with moderately large eye; distinguished from all species of this group, except *D. tasmaniensis* Baehr, 2005 and *D. dilatatus* (Erichson 1842) from Tasmania, by presence of 3 punctures on the apical part of the 7th interval. From *D. tasmaniensis* distinguished by larger size and lack of a dark ring on the femora; and from *D. dilatatus* by much smaller eye, wider prothorax, and unisetose 3rd interval.

Description. *Measurements.* Length: 5.6 mm; width: 2.4 mm. Ratios. Length eye/orbit: 2.9; width/length of pronotum: 1.54; width base/apex of pronotum: 1.41; width pronotum/head: 1.36; length/width of elytra: c.1.62; width elytra/pronotum: c.1.68.

Colour (Fig. 5). Surface, including mouth parts and antenna, pale rufous, legs dark yellow. Lateral margins of pronotum and elytra barely lighter.

Chaetotaxy. pr: 0, 1; el: 1, 0, 3; ab: ?, 6.

Head (Fig. 5). Rather large, but considerably narrower than pronotum, frons in middle convex. Eye large, laterally well protruded. Orbit rather short, c. 1/3 of length of eye, oblique, evenly merging into curvature of eye, forming a fairly distinct angle with neck. Labrum anteriorly straight. Mandibles short and wide. Submentum apparently asetose. Tooth of mentum large, wide, rather acute. Glossa apically straight, bisetose, paraglossae hyaline, slightly surpassing glossa. Lacinia with a few strong spines. Both palpi rather short, obliquely cut at apex, impilose. Antenna fairly elongate, surpassing base of pronotum by slightly < two antennomeres. Median antennomeres c. 2 x as long as wide. Posterior supraorbital seta slightly removed from eye, situated slightly behind posterior margin of eye. Frontal furrows rather elongate, moderately deep, linear, oblique and sinuate. Frons without any distinct impression in middle. Surface impunctate, without microreticulation, very glossy.

Pronotum (Fig. 5). Fairly wide, considerably wider than long, with wide base, disk rather convex, widest diameter in middle. Apex with very shallow, almost straight excision, apical angle little protruded, widely rounded. Lateral margin gently convex throughout, more so in apical half, very slightly concave in front of the basal angle. Basal angle rectangular, laterally very slightly produced. Base in middle convex, laterally oblique and slightly sinuate. Apex not margined, base coarsely margined. Marginal channel moderately wide, deep, barely widened towards base, margin upturned. Median line distinct and slightly impressed, almost reaching apex and base. Anterior transversal sulcus very shallow, posterior sulcus moderately impressed. Basal grooves linear, almost straight, deep, separated from marginal channel. Posterior lateral seta arising at lateral margin on basal angle. Surface with very fine transverse strioles, with scattered, extremely fine, barely perceptible punctures, without microreticulation, very glossy.

Elytra (Fig. 5). Moderately elongate, gently oval shaped, slightly widened posteriad, disk moderately convex. Humerus angulate, slightly protruded, basal margin gently angulate. Lateral margin at apex convex. Lateral apical fold strong. Seven striae distinct and well impressed, even 7th stria slightly < impressed. Striae rather coarsely punctate; intervals gently convex. 3rd interval with one setiferous puncture, situated slightly behind the apical quarter and at the median side of the 3rd stria. 7th stria with three punctures in apical fifth. Marginal channel with 13-14 setiferous punctures, series slightly interrupted behind middle, punctures fine. Apparently one additional setiferous puncture located near apex at the end of the 3rd stria. Intervals with

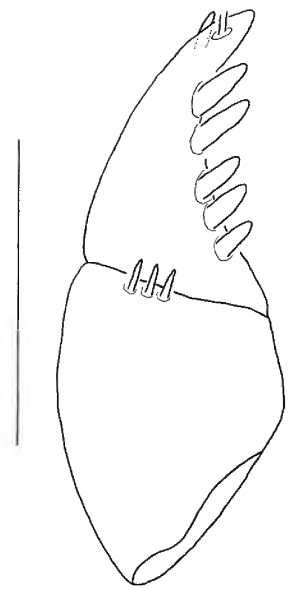

FIG. 9. *Dystrichothorax trisetosus* sp. nov. Female gonocoxites 1 and 2. Scale bar: 0.2 mm.

a series of extremely fine punctures, with fine, rather superficial microreticulation consisting of fairly transverse meshes. Surface moderately glossy.

Posterior wings. Fully developed.

Lower surface. Metepisternum elongate, c. 2 x as long as wide at apex.

Male genitalia. Unknown.

Female genitalia (Fig. 9). Gonocoxite 1 with three small ensiform setae at apical margin. Gonocoxite 2 elongate, curved, with rather acute apex; with one elongate dorso-median ensiform seta close to apex, 5 large, ventro-lateral ensiform setae along the lateral margin, and two very short nematiform setae near apex, originating from a pit. Lateral plate on ventro-apical part densely packed with many short ensiform setae.

Variation. Unknown.

Distribution. New England Tableland, north-eastern New South Wales, Australia. Known only from type locality.

Collecting circumstances. Sampled by pyrethrum on trees in open forest at high altitude.

Relationships. In view of the yet unknown male genitalia the relations of this species are unsettled.

Remarks. The biology of the new species is barely recorded. However, because all specimens have been sampled by pyrethrum fogging or 'barkspray' on tree trunks, they all seem to be arboricolous and corticolous species like their congeners. Most specimens have been collected in *Nothofagus* forest or unspecified rain forest, where they may live under bark. All species have been sampled at rather high to high altitudes from about 700 m up to more than 1400 m.

The present paper therefore demonstrates that the species inventory of Australian Amblytelina is by no means complete, in spite of the recent revision (Baehr, 2005) that included almost all specimens then present in the Australian and various overseas collections. The fact that, even in well collected areas such as south-eastern Queensland and north-eastern New South Wales, additional species are still being discovered, confirms this opinion. Certainly the method of spraying bark of rain forest trees is the best way to detect additional species, because prior to the application of this method most described amblyteline species had been found by bark peeling of bark-shedding eucalypts in open forest and woodland.

Despite improved taxonomic knowledge of these beetles, little has been recorded about their ecology, ethology, and reproduction. Because amblyteline beetles are rarely found at night at light, they don't seem to be nocturnal animals. However, even on densely populated trees (in open forest and woodland) during daytime they are very rarely seen on the bark or trunk surface. For rain forest inhabiting species even less is known about their habits.

Another unsolved question is the reason for the degree of brightness in the colour patterns of a number of species, e.g. the conspicuously striped elytra of many species. Striking colour patterns seem less

common in rain forest inhabiting species than in those living under the bark of eucalypts in open forest. Such striped species are commonly found in communities with a number of lebiine species from various genera (*Agonocheila, Demetrida, Philophloeus, Phloeocarabus, Trigonothops*) and with species of the cyclosomine genus *Sarothrocrepis*, all of which commonly possess similar colour patterns. The meaning of these similarities is likewise unknown.

KEYS

The species are introduced into the respective keys in the revision (Baehr 2005). Figures in the revision are cited as Ba2005 fig.

Amblytelus suturalis

When using the key for the genus *Amblytelus*, according to body shape, chaetotaxy, length of elytra, and shape of aedeagus, couplet 44 is reached which must be changed as following:

44 Body distinctly bicoloured, head and pronotum rufous, elytra dark piceous with conspicuous red suture and lateral margin (Ba2005 fig. 176); eye smaller, ratio eye/orbit <3; aedeagus with laterally sharply angulate apex (Ba2005 fig. 52). e. VIC, ACT ..... *matthewsi* Baehr, 2005

— Body not distinctly bicoloured, but elytra with or without a sutural spot (Fig. 1; Ba2005 figs 170, 173); eye larger, ratio eye/orbit >3.5; aedeagus with laterally rounded apex (Fig. 6; Ba2005 fig. 47), or unknown ..... 45.

45 Elytra with distinct pale sutural spot (Fig. 1); eye larger, ratio eye/orbit > 5.5; aedeagus with less curved apex (Fig. 6). ne. NSW ..... *suturalis* sp. nov.

— Elytra at most with inconspicuous sutural spot (Ba2005 fig. 170); eye smaller, ratio eye/orbit < 4.0; aedeagus with more curved apex (Ba2005 fig. 47), or unknown, in latter species elytra unicolourous. ce. NSW, sw. Tas ..... 45a.

45a = 45. in Baehr (2005).

Dystrichothorax wrightae and *D. rufinus*

When using the key for the genus *Dystrichothorax*, according to body shape, chaetotaxy, colour, and shape of aedeagus couplet 43 is reached which must be changed as following:

43 Elytra unipunctate and colour uniformly pale rufous and prothorax rather wide, ratio w/l > 1.36 and elytra rather short, ratio l/w 1.55 (Fig. 4) ..... *rufinus* sp. nov.

— Elytra uni- or bipunctate; but when unipunctate, colour darker, prothorax narrower, ratio w/l < 1.28, and elytra longer, ratio l/w > 1.58, usually more ..... 43a.

43a Aedeagus remarkably compact, wide, distinctly widened in middle; margin on left side in front of apex very deeply excised, apex short, tip curved to left side (Ba2005 figs 94, 95) ..... .44.

— Aedeagus less compact, narrower, not or barely widened in middle; margin on left side in front of apex less deeply excised, apex commonly longer, tip less markedly curved to left side (Fig. 7; Ba2005 figs 90-92, 96, 97) ..... 45.

45 Apical half of internal sac with large, conspicuously denticulate sclerite at roof (Fig. 7; Ba2005 fig. 92); elytral striae rather deeply impressed, intervals in basal half perceptibly convex ..... .45a.

— Apical half of internal sac with two small, denticulate sclerites at roof and at bottom (Ba2005 figs 91, 96), or without denticulate sclerites (Ba2005 figs 90, 97); elytral striae usually less deeply impressed, intervals in basal half but slightly convex, or depressed ..... 46.

45a Margin on left side of aedeagus in front of apex moderately excised (Ba2005 fig. 92); pronotum laterally more oblique, slightly wider; elytra slightly shorter, striae deeper and intervals in basal half more convex. ne. NSW ..... *catrionae* Baehr, 2005

— Margin on left side of aedeagus in front of apex deeply excised (Fig. 7); pronotum laterally straight, slightly narrower; elytra slightly longer, striae less deep

and intervals in basal half little convex. se. QLD. . . . . *wrightae* sp. nov.

46 As in Baehr (2005).

Dystrichothorax capitis

When using the key for the genus *Dystrichothorax*, according to body shape, chaetotaxy, colour, and shape of aedeagus couplet 37 is reached which must be changed as following:

37 Pronotum narrow, ratio w/l <1.20; base relatively narrow, ratio b/a <1.49; margin on left side of aedeagus near apex deeply sinuate, apex slightly hook-shaped, turned right and curved up (Ba2005 fig. 93). Lamington Plateau, se. QLD . . . . . *hamifer* Baehr, 2005

— Pronotum wider, ratio w/l >1.20; base wider, ratio b/a >1.52; either aedeagus narrow and elongate, with more or less evenly tapering apex (Fig. 8; Ba2005 fig. 88), or unknown. . . . . 38.

38 Lateral margins of pronotum almost straight, base of pronotum about as wide as in middle, or even wider (Fig. 3; Ba2005 fig. 219); elytral striae distinctly impressed, intervals convex even in basal half; aedeagus narrow and elongate (Fig. 8; Ba2005 fig. 88). ne. NSW, se. QLD . . . .38a.

— Lateral margins of pronotum perceptibly convex, base of pronotum distinctly narrower than in middle (Ba2005 fig. 228); elytral striae but slightly impressed, intervals in basal half little convex; aedeagus unknown. Richmond Range, extreme ne. NSW . . . . . *piceus* Baehr, 2005

38a Head not perceptibly paler than pronotum and elytra; aedeagus with evenly tapering apex, without a denticulate fold in apical part (Ba2005 fig. 88). ne. NSW, se. QLD . . . . . *difficilis* Baehr, 2005

— Head perceptibly paler than pronotum and elytra (Fig. 3); aedeagus with slightly excised apex, with a denticulate fold in apical part (Fig. 8). se. QLD. . . . . *capitis* sp. nov.

Dystrichothorax trisetosus

When using the key for the genus *Dystrichothorax*, according to chaetotaxy couplet 17 is reached which must be changed as following:

17 Elytral interval 7 multisetose; either both parameres very elongate (Ba2005 fig. 100), or, in case of unknown male genitalia, body size larger, length > 5.6 mm. 18

— Elytral interval 7 unisetose; either both parameres short (Ba2005 figs 101, 102), or, in case of unknown male genitalia, body size smaller, length <5.4 mm. 19

18 Body size smaller, length < 5.3 mm; femora with conspicuous dark ring; aedeagus and parameres as in Ba2005 fig. 100. TAS . . . . . *tasmaniensis* Baehr, 2005

— Body size larger, length > 5.6 mm; femora without such dark ring; aedeagus unknown 18a

18a Body size larger, length c. 5.9 mm; eye very large, ratio length eye/orbit c. 5.0; prothorax narrower, ratio w/l 1.42; 3rd interval impunctate; gonocoxites unknown. TAS . . . . . *dilatatus* (Erichson, 1842)

— Body size smaller, length c. 5.6 mm; eye smaller, ratio length eye/orbit c. 2.9; prothorax wider, ratio w/l 1.54; 3rd interval unipunctate; gonocoxite 2 with five ventro-lateral ensiform setae (Fig. 9). ne. NSW . . . . . *trisetosus* sp. nov.

19 As in Baehr (2005)

ACKNOWLEDGEMENTS

My sincere thanks are due to Christine Lambkin, Susan Wright, and Geoff Monteith of Queensland Museum, Brisbane, for the kind loan of museum specimens.

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New species of the genera *Sphallomorpha* Westwood, 1837 and *Adelotopus* Hope, 1834 from Queensland, Australia (Insecta: Coleoptera: Carabidae: Pseudomorphini)*

* 15th supplement to the "Revision of the Pseudomorphinae of the Australian Region".

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ABSTRACT

Three new pseudomorphine carabid species of the genera *Sphallomorpha* Westwood, 1837 and *Adelotopus* Hope, 1834 are described from Queensland, Australia: *Sphallomorpha cognata* and *A. leviusculus* from south-eastern Queensland, and *Adelotopus moffatti* from central Queensland. The new species are compared with their nearest relatives and introduced in the keys to the respective genera. ❒ *Coleoptera, Carabidae, Pseudomorphini, Sphallomorpha, Adelotopus, new species, Australia*

Within a sample of recently collected carabid beetles, received from Queensland Museum, Brisbane, I detected, *inter alia*, three new species of the pseudomorphine genera *Sphallomorpha* Westwood, 1837 and *Adelotopus* Hope, 1834, from south-eastern and central Queensland that are described in the present paper.

Pseudomorphini (or -inae, according to the opinion of the respective workers) is a moderately large tribe (or subfamily) of Carabidae of outstanding shape and structure, and has a very specialised biology. The tribe mainly occurs in Australia and North and South America, but a few species of the genera *Sphallomorpha* Westwood, 1837 and *Adelotopus* Hope, 1834 have been recorded from New Guinea, Solomon Islands, Java, and the Moluccas (Baehr 2009a), and one species of the genus *Cryptocephalomorpha* Ritsema, 1875 even occurs in southern Africa, whereas most species of this small genus live in southern and south-eastern Asia (Baehr 2013). According to present knowledge the tribe is most diverse, with respect to body shape and structure, in Australia, where six very differently shaped genera occur (Baehr 1992, 1997, 2002, 2005, 2006, 2008, 2009b, 2014). The American species have not yet been revised, and until recently they were combined in a single genus *Pseudomorpha* Kirby, 1825. Certainly they are far less diverse in their morphology than the Australian Pseudomorphini. Baehr

(1997) erected two subgenera of *Pseudomorpha*, namely *Austropseudomorpha* Baehr, 1997 for the few Australian species, and *Notopseudomorpha* Baehr, 1997 for a few apparently more plesiotypic South American species. However, more recently the genus *Pseudomorpha* has been divided into several genera (Erwin & Geraci 2008), and the subgenera erected by Baehr have been raised to generic rank. When studied more satisfactorily in future, according to Erwin & Geraci (2008), the American species may nearly equal the number of Australian species.

Most pseudomorphine species are more or less depressed, possess depressed legs and a reduced chaetotaxy. Depending on the genera to which they belong, their habitus is very similar to either water beetles of the families Dytiscidae or Hydrophilidae, or wood inhabiting Scolytidae or even Colydiidae. Among the Australian pseudomorphine fauna a gradient is evident from depressed species with prognathous mouth parts, elongate antenna, elongate legs, fairly complete chaetotaxy, and normal shaped female gonocoxites (genus *Sphallomorpha*), to cylindrical body shape, orthognathous mouth parts, short antenna, short, very depressed legs, very much reduced chaetotaxy, and foliaceous female gonocoxites (*Austropseudomorpha* → *Adelotopus* → *Cainogenion* → *Paussotropus*). The species of most genera are ovoviviparous (*i.e.* larviparous) which mode of reproduction is very rare within Carabidae and generally within beetles. The most plesiotypic pseudomorphine genus *Sphallomorpha*, however, is still oviparous.

In Australia the number of species and subspecies is 308 at present, and pseudomorphine beetles occur in all parts of the continent. Almost all species have been found either under the bark of bark shedding trees (mainly eucalypts), or in deep crevices in the bark of other trees, including non-eucalypts, usually in more or less open forest and woodland, but a few species have invaded rain forest, where they may be found on the bark of moss covered trees. The habits of the single species of *Paussotropus* Waterhouse, 1877 and the single Australian species of *Cryptocephalomorpha* Ritsema, 1875 have not yet been recorded, but it is suggested that all pseudomorphine species live in connection with ants, a few even with termites (Baehr 1992, 1997). However, this is actually recorded from only a few species. The larviparous reproduction of most genera likewise may be related to the myrmecophilous habits of the larvae. Similarly, the increasing trend towards development of physogastric larvae in the higher evolved genera is regarded an adaptation to that mode of life.

METHODS

For the taxonomic treatment standard methods were used. The genitalia were removed from specimens relaxed for a night in a jar under moist atmosphere, then cleaned for a short while in hot 10% KOH. The habitus photographs were taken with a digital camera using ProgRes CapturePro 2.6 and AutoMontage and subsequently were worked with Corel Photo Paint X4.

Measurements were taken using a stereo microscope with an ocular micrometer. Body length was measured from apex of labrum to apex of elytra, length of pronotum along midline, length of elytra from the most produced part of the humerus to the most produced part of the apex.

For the chaetotaxy which is very important for the identification of species of *Sphallomorpha*, the abbreviations as used in Baehr (1992) are repeated below.

The holotypes of the new species are stored in Queensland Museum, Brisbane (QM), while a few paratypes are retained in the working collection of the author at Zoologische Staatssammlung, München (CBM). Label data of specimens are given verbatim, including all ciphers and printed labels. Also original spelling of the collecting date is used.

Chaetotaxy

supraorb	supraorbital seta (either side)
preorb	preorbital seta (either side)
clyp	clypeal seta (either side)
labr	labral setae (common)
ment.med	medial mental setae, at base of mental excision or mental tooth (common)
ment.lat	lateral mental setae, on wings of mentum (either side)
gloss	glossal setae, on ventral rim of apex of glossa (either side)
gul	gular setae, inside of gular suture (either side)
postorb	postorbital setae, posteriorly of eye on a conspicuous rim (either side)
suborb	suborbital setae, below eye, laterally of gular suture (either side)
pron.ant	anterior pronotal setae, near anterior angle of pronotum (either side)
pron.post	posterior pronotal setae, near posterior angle of pronotum (either side)
proeps	proepisternal setae, longitudinally and transversally on proepisternum (either side)
marg	marginal setae, along margin of elytra (either side)
st VI	setae on posterior border of sternum VI, the penultimate visible sternite (either side)
♂ st VII	setae of male sternum VII, the terminal visible sternite (either side)
♀ st VII	setae of female sternum VII, the terminal visible sternite (either side)

Genus *Sphallomorpha* Westwood

Westwood, 1837: 414. – For additional literature records and diagnosis see Baehr (1992).

Type species. *Sphallomorpha decipiens* Westwood, 1837, by monotypy.

Diagnosis. Wide, depressed species with prognathous head, elongate antenna, elongate legs, comparatively complete chaetotaxy, normal shaped, not foliaceous female gonocoxites, and barely physogastric larvae. As far as it is recorded, all species of this genus are oviparous. In males the terminal sternum is excised, and in both sexes it bears a varied number of elongate setae at the apical margin.

Note. As Baehr (1994a) demonstrated, *Sphallomorpha* is plesiomorphic in many character states as compared with the other pseudomorphine genera, and thus, it represents the adelphotaxon of all other genera of Pseudomorphinae.

The genus *Sphallomorpha* includes 157 species at present, of which only 8 occur outside of Australia in New Guinea (Baehr 1992, 1993a, b, 1994b, 2002, 2004, 2005, 2006, 2008, 2009a, b, 2010, 2014). Species of *Sphallomorpha* usually are wide and rather depressed, they are either unicolourous black or piceous, or bear various, sometimes very vivid, colour patterns on the elytra and/or the pronotum. In Australia they occur in a great variety of habitats, provided that some tree growth is present, but appear to be very rare in rain forest. The Australian species are known to live under the loose bark of tree trunks of various eucalypts or in deep bark crevices on rough-barked eucalypt and non-eucalypt trees. They are extremely agile, fast running beetles which fly deliberately, but are quite rarely encountered at light. The larvae of the very few species of which the larvae were recorded, apparently live with ants (Moore 1974), but are not decidedly physogastric as are the recorded larvae of the other pseudomorphine genera (Baehr 1997).

Baehr (1992) divided the genus into a number of putative monophyletic species groups which combine species that share certain synapomorphic character states of the external or genitalic morphology. According to certain character states of external and male and female genitalic morphology, as mentioned in the key of Baehr (1992), the species described below belongs to the *parva*-group of the revision.

Sphallomorpha cognata sp. nov.
(Figs 1, 4)

Material. HOLOTYPE: ♂, QLD: 25.829°SX151.071°E Inskip Point, 10m, 4 Feb2013 G.Monteith, barkspray, cypress/eucs, sandy 35470" (QMT234149).

Etymology. The name refers to the close similarity of body shape and structure of the aedeagus as

FIGS 1-3. Habitus. Body lengths in brackets. **1**. *Sphallomorpha cognata* sp. nov. (9.5 mm). **2**. *Adelotopus moffatti* sp. nov. (6.2 mm). **3**. *Adelotopus leviusculus* sp. nov. (5.35 mm).

compared with *S. politoides* Baehr, 1997 and the apparent close relationship with that species.

Diagnosis. A moderately large, fairly wide, moderately convex, unicolourous black species without mental tooth but with angulate gular sutures, and with faint elytral striation. It belongs to the *parva*-group of the revision and in view of body size, elytral striation, and structure of the aedeagus it is most similar, and probably nearest related, to *S. politoides* Baehr, 1997. Main differences from *S. politoides* are: barely raised elytral intervals, absence of the posterior marginal pronotal seta, lesser number of marginal setae on the elytra, and differently structured internal sac of the aedeagus.

Description. *Measurements*. Length: 9.5 mm; width: 5.2 mm. Ratios: Width pronotum/head: 1.72; width elytra/pronotum: 1.12; width/length of pronotum: 2.55; length/width of elytra; 1.21; length elytra/pronotum: 3.50.

Colour (Fig. 1). Black, lateral margins of pronotum and elytra barely paler, labrum and mandibles piceous, palpi, legs, and lower surface rufous, antenna yellow.

Chaetotaxy. Supraorb: 1; preorb: 1, clyp: 1; labr: 4; ment.med: 2; ment.lat: 3-4; gloss: 4; gul: 1; postorb: 3; suborb: 4-5; pron.ant: 1; pron.post: -; proeps: 1 + 4; marg: 13-14; st VI: 2; ♂ st VII: 8-10; ♀ st VII: ?.

Head (Fig. 1). Of average size, fairly depressed, without distinct frontal impressions. Eye large, laterad well projected. Clypeus slightly concave, clypeal suture barely indicated. Lateral border of head convex, incurved in front of the eye. Labrum wide, almost straight, with a faint median sinuosity. Mentum without tooth. Wings of mentum wide, convexly triangular, at apex rounded. Glossa in middle fairly excised, slightly excavate. Dorsal part barely surpassing the ventral one. Gular sutures angulate. Palpi sparsely pilose. Terminal palpomere of both

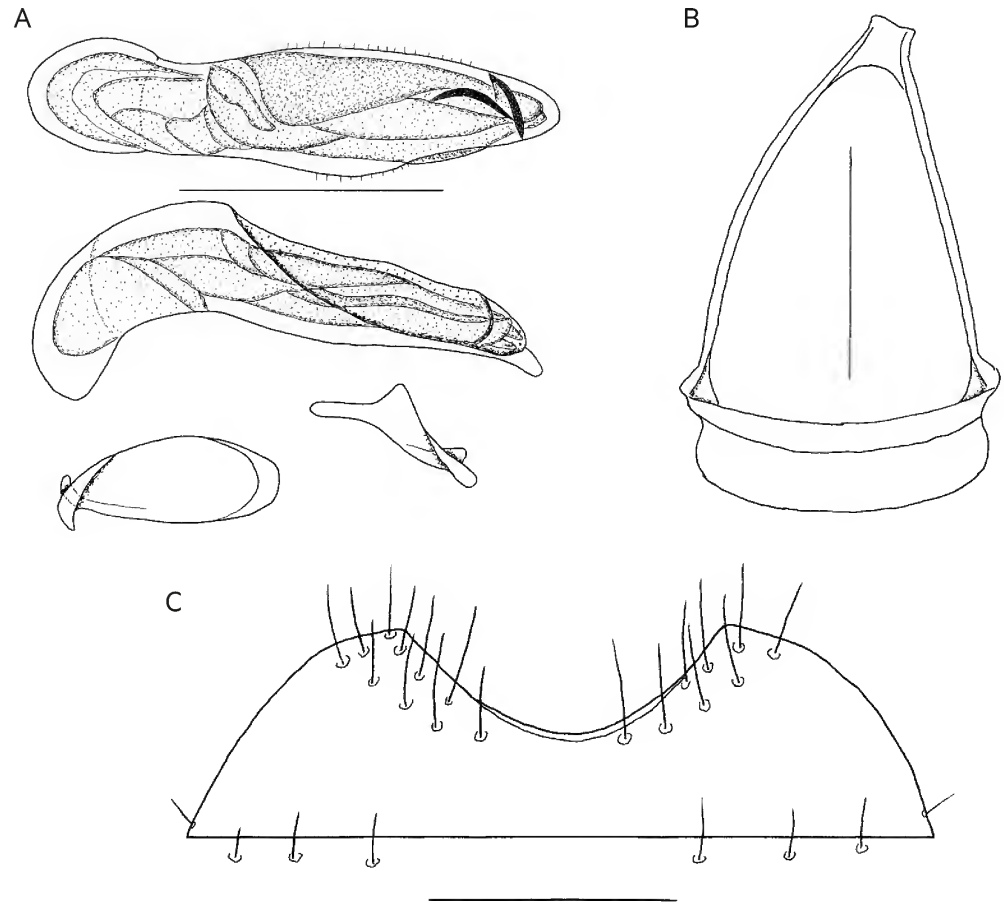

FIG 4A-C.*Sphallomorpha cognata* sp. nov. **A**, Male genitalia: aedeagus, left side, lower surface, parameres. Scale bar: 1 mm; **B**, Male genital ring. Scale bar: 1 mm; **C**, Male terminal sternum.Scale bar: 1 mm.

palpi narrow and elongate, with oblique apex, not securiform. Galea elongate, moderately large, with some very short hairs along anterior border and at apex. Antenna rather elongate, median antennomeres < 3 x as long as wide. Medially of eye with a few shallow longitudinal strioles, also in middle with short irregular strioles. Centre of frons with a shallow impression on either side. Microreticulation of dorsal surface dense and distinct, fine, isodiametric. Punctures rather sparse, fine, and difficult to detect within the microreticulation. Surface with sparse and fine, erect pilosity, which is only visible when viewed from side, surface fairly dull. Ventral surface with very sparse, short, erect pilosity.

Pronotum (Fig. 1). Rather wide, fairly convex, convexly quadrangular, lateral margins not explanate. Apex wide, with rather deep excision. Anterior angle projected, but rounded. Lateral margin evenly convex, widest immediately in front of the base. Basal angle shortly rounded. Base almost straight. Lateral margin with very fine border line. Apex only laterally very finely bordered, base not bordered. No discal impressions visible. Microreticulation dense and fairly distinct, isodiametric, punctures dense

and moderately coarse, clearly visible, surface with sparse, short, erect pilosity, rather dull.

Elytra (Fig. 1). Moderately elongate, little narrowed apicad, widest shortly behind base, dorsal surface moderately convex. Lateral margins almost evenly convex, not explanate. Apex slightly oblique and convex. Base without a scutellary seta and pore. Striae faint, at base reduced, increasingly so in the lateral striae, all striae impunctate. Intervals very faintly convex except near base. Series of marginal pores rather spaced in middle. Microreticulation dense and distinct, isodiametric, punctures dense and moderately coarse, clearly visible, surface with sparse, short, erect pilosity, rather dull.

Lower surface. Prosternal process elongate, narrow, apex almost straight, ventral surface convex, straight to apex, impilose. Metepisternum slightly > 2 x as long as wide at apex. Excision of terminal abdominal sternum in male wide and shallow, with 9-11 elongate setae on each side.

Legs. Elongate, slender. Metatarsus as long as metatibia. 1st tarsomere of metatarsus as long as 2nd and 3rd tarsomeres together. 1st - 3rd tarsomeres of male protarsus biseriately pilose.

Male genitalia (Fig. 4). Sternum VII wide and rather short, with wide, fairly deep, and slightly v-shaped excision. Genital ring wide, triangular, slightly symmetric, basal border feebly convex, lateral angles rounded, basal plate wide, short, barely excised, apex narrow, oblique. Aedeagus short and wide, straight, but slightly asymmetric, in middle gently convex, lower border in middle slightly convex, near apex slightly concave. Lateral margins in middle with a row of very short hairs. Apex short, wide, convexly triangular, rounded at tip, depressed, slightly directed down. Orificium elongate. Internal sac near apex with two sclerotized rods and with several large, more or less twisted folds. Both parameres elongate, the right paramere in the apical part narrow, straight, rounded at apex, the left paramere slightly ovoid, with obtusely convex apex.

Female gonocoxites. Unknown.

Variation. Unknown.

Distribution. South-eastern Queensland, Australia. Known only from type locality on the coast just north of the town of Rainbow Beach.

Collecting circumstances. Sampled by pyrethrum bark spray in mixed cypress and eucalypt forest on sandy soil. Certainly this is a bark inhabiting species like its congeners.

Genus *Adelotopus* Hope

Adelotopus Hope, 1834: 11 – Baehr 1997: 51.

Type species. *Adelotopus gyrinoides* Hope, 1834, by monotypy.

Diagnosis. Comparatively narrow, moderately depressed to convex species with almost orthognathous head, short antenna, wide, rather short legs, reduced chaetotaxy, foliaceous female gonocoxites, and moderately physogastric larvae. As far as it is recorded, all species of this genus are ovoviviparous. The terminal sternum is similarly shaped in both sexes.

Note. With 135 described species at present, *Adelotopus* is the second largest genus of Australian Pseudomorphini. Species of *Adelotopus* are more or less elongate, dorsally rather convex, mostly unicolourous black or reddish-brown, but some bear a red elytral apex or differently shaped, yellow or rufous discal spots. The head is short and more or less directed ventrad, so that the mouth parts are barely visible from above, and the pronotum and the elytra cover most of the usually rather short legs. The chaetotaxy is generally very much reduced, the terminal abdominal sternum does not exhibit striking sexual differences, and the male genitalia generally are rather similarly shaped and structured. The female gonocoxites are also very similar in most species. They are foliaceous and bear a few setae. Through the many reductions, distinction of species is difficult and, apart from examination of the genitalia, needs measurements and examination of the few remnants of chaetotaxy and of the surface structure, *i.e.* striation of the elytra, punctation, and microreticulation.

With respect to the reduced chaetotaxy and the unique foliaceous female gonocoxites this genus is apotypic within Pseudomorphini and

it shares the ovoviviparous reproduction with all other genera except *Sphallomorpha Westwood, 1837* and perhaps also *Cryptocephalomorpha Ritsema*, 1875, where it has not been detected due to very rare material, but yet may be present.

Most species of *Adelotopus* occur in Australia. A few species are recorded from New Guinea, Solomon Islands, the Moluccas, Java, and southernmost mainland Malaysia. In Australia species of *Adelotopus* occur everywhere, provided some tree growth is present, but apparently not in dense rain forest. Species of this genus are found under bark of shedding eucalypts and in bark crevices of various trees. The larvae are somewhat physogastric and apparently myrmecophilous, but very few larvae have been detected so far.

Baehr (1997) divided the genus into a number of putative monophyletic species groups which combine species that share certain synapomorphic character states of the external or genitalic morphology. According to these character states of external and male and female genitalic morphology the species described below belong to the *politus*-group of the revision.

Adelotopus moffatti sp. nov.
(Figs 2, 5, 6)

Material. HOLOTYPE: ♂, QLD: 24.924°SX148.065°E Mt. Moffatt NP, Mahogany Forest, 1200 m, 15-16 Jan 2013, G.Monteith barkspray, O/F 35452 (QMT234152). PARATYPES: 3♂♂, 1♀, same data (CBM, QM); 1♀, QLD: 25.020°SX147.929°E Mt. Moffatt, 2 km W of HQ, 16 Jan 2013, G.Monteith barkspray, O/F 35450 (QM); 2♂♂, Qld: 24.790°Sx147.846°E Carnarvon Stn, nr Blue Water Spring 14 Oct 2014, D.Tree. 879 m. Pyrethyum knockdown. Eucalypt. 37124 (CBM, QM).

Etymology. The name refers to the type locality, Mt. Moffatt National Park.

Diagnosis. Species of the *politus*-group of the revision by virtue of the basal margin of the elytra which almost attains the suture. Within the group it belongs to a subgroup of uniformly black species. Distinguished from the most similar species *A. politus* Castelnau, 1867, by wider prothorax and elytra and by 4-5, instead of 3, apical setae on gonocoxite 2.

Description. *Measurements.* Length: 6.1-6.6 mm; width: 2.7-2.8 mm. Ratios. Width/length of pronotum: 1.84-1.90; width base/apex of pronotum: 1.63-1.68; width pronotum/head: 1.65-1.75; length/width of elytra: 1.46-1.53 length elytra/pronotum: 2.64-2.75.

Colour (Fig. 2). Black, pronotum and elytra with the lateral margins narrowly dark rufous translucent. Palpi dark, antenna, femora, and tarsi rufous, tibiae black. Lower surface dark piceous to black.

Head (Fig. 2). Short and wide, moderately depressed. Anterior border gently convex, lateral angle obtusely rounded, laterally slightly projecting, lateral borders distinctly oblique. Clypeal suture very fine or almost absent, semicircular, in middle interrupted. Labrum narrow, mostly concealed by the clypeus, apex faintly concave, bisetose. Antennal groove laterally not bordered, latero-posteriorly with a weakly carinate area. Mental tooth triangular, short, apex acute. Wings of mentum wide, laterally rounded, apex oblique. Mentum laterally on either side with a pit. Glossa wide, tongue-like, apically convex, ventrally with indistinct keel, at border with c. 12 elongate setae and additional pilosity on upper and lower surfaces and along border. Terminal palpomere of maxillary palpus widened apicad, slightly securiform. Terminal palpomere of labial palpus very wide, markedly securiform. Antenna short, 8th - 9th antennomeres almost 2 × as wide as long. Dorsal surface with a shallow sulcus medially of the eye, impilose, with extremely fine though distinct, isodiametric microreticulation and minute punctures barely recognisable even at high magnification. Ventro-laterally of the eye with few short setae. Suborbital field impunctate and asetose. Gula apparently asetose.

Pronotum (Fig. 2). Wide, dorsally convex, base wide, markedly narrowed to apex. Apical angle well produced, at apex angulate, somewhat oblique, well surpassing the posterior margin of the eye. Apex moderately excised, slightly convex in excision, very faintly bordered. Lateral margin gently convex, in basal half

almost straight. Marginal sulcus narrow, slightly widened apicad. Basal angle obtusely angulate, but shortly rounded at the very tip. Base almost straight, not or very indistinctly bordered. Surface near base without transverse impression. Marginal setae absent. Microreticulation extremely fine, somewhat superficial, isodiametric to slightly transverse, punctation extremely fine, on disc barely recognisable, laterally slightly more distinct, surface impilose, moderately glossy.

Elytra (Fig. 2). Rather short and wide, dorsally convex, little narrowed to apex, sides in basal half straight. Apex wide, slightly oblique and faintly convex, apical angles shortly rounded. Humerus rounded, basal margin short, slightly oblique. Marginal channel narrow, but visible even near apex. Basal border very fine, almost complete, but not attaining suture. Lateral border asetose except for a series of 5-6 setae at humerus. Series of umbilical pores consisting of 6 regularly set pores behind humerus and a single pore in apical half. Setae short. Striae not recognisable. Scutellary pore and stria absent. Microreticulation extremely fine and superficial, isodiametric, visible only at very high magnification, punctation rather sparse and very fine, likewise only perceptible at very high magnification, surface impilose, glossy.

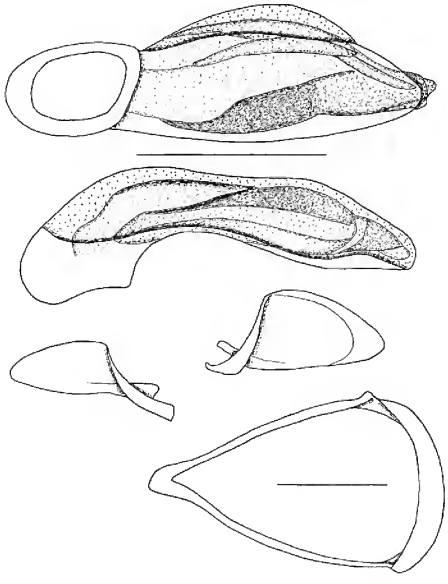

FIG. 5. *Adelotopus moffatti* sp. nov. Male genitalia: aedeagus, left side, lower surface, parameres, genital ring. Scale bars: 0.5 mm.

Lower surface. Prosternal process rather short, fairly wide, straight, gently convex, apex wide and rather short, margin depressed, slightly convex, shortly setose. Metepisternum moderately elongate, c. 1.5 × as long as wide, in posterior third obliquely bent and deeply hollowed. Abdominal sterna bisetose and with rather sparse but fairly elongate, slightly declined pilosity. Terminal sternum without longer setae along apical border.

Legs. Rather short, 1st tarsomere of protarsus about as wide as long, tibial groove of profemur deep, anterior plate widely overlapping the groove for the apical third, posterior border of groove sharp. Femur wide. Metatibia medium-sized, slightly > 4 x as long as wide, 1st tarsomere of metatarsus c. 1.5 x as long as wide. Three basal tarsomeres of male protarsus squamose beneath.

Male genitalia (Fig. 5). Genital ring wide, convexly triangular, almost symmetric, with narrow apex and wide, little excised base. Aedeagus short and wide, depressed, in middle markedly widened, asymmetric. Lower surface convex, not striped. Apex wide, triangularly convex, at tip rounded, symmetric. Orificium very elongate, internal sac with several folds, one of which is more distinctly sclerotized than the others, near apex with a distinct, oblique fold. Both parameres large, convexly triangular, with obtuse apex, left paramere considerably larger than the right one.

Female gonocoxites (Fig. 6). Gonocoxite rather narrow, apex wide, about transverse; with 3-4 elongate apical setae. Lateral plate fairly elongate, at the rounded medio-apical angle with 2-3 elongate setae.

Vivipary. Not recorded.

Variation. Little variation noted.

Distribution. Area of Carnarvon Range, central Queensland.

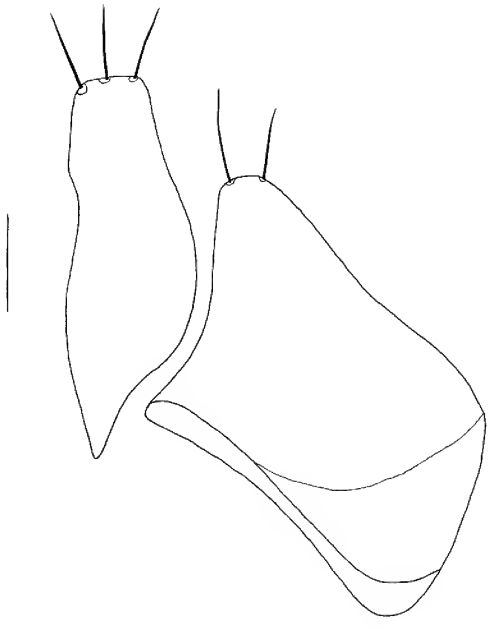

FIG 6. *Adelotopus moffatti* sp. nov. Female gonocoxites. Scale bars: 0.25 mm.

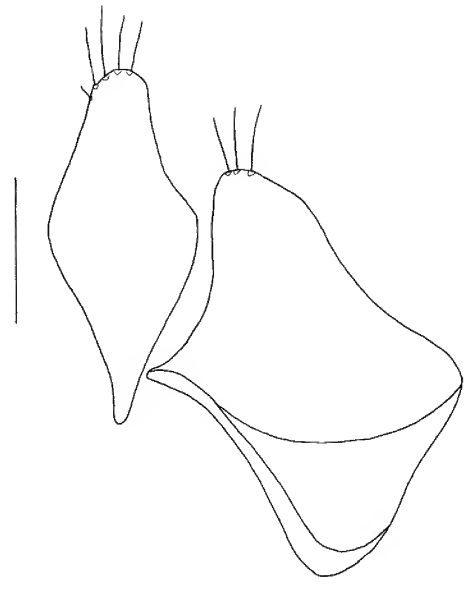

FIG. 7. *Adelotopus leviusculus* sp. nov. Female gonocoxites. Scale bars: 0.25 mm.

Collecting circumstances. All specimens were collected by pyrethrum spray in eucalypt forest.

Relationships. This species is very similar, and probably closely related, to *A. politus* Castelnau, 1867.

Adelotopus leviusculus sp. nov.
(Figs 3, 7)

Material. Holotype: ♀, Qld: 28°02.8'Sx153°07.2'E Glen Witheren, main scrub 3 Nov 2007 130 m G.B.Monteith. rainforest pyrethrum, trees. 15398" (QMT234151).

Etymology. The name refers to the comparatively glossy, very inconspicuously punctulate elytra.

Diagnosis. Species of the *politus*-group of the revision by virtue of the basal margin of the elytra which almost attains the suture. Within the group it belongs to a subgroup with a red apex of the elytra. Distinguished from the most similar species *A. semilunatus* Baehr, 1997, by even finer microreticulation and punctation, and by longer and laterally almost straight elytra.

Description. *Measurements.* Length: 5.35 mm; width: 1.45 mm. Ratios. Width/length of pronotum: 1.17; width base/apex of pronotum: 1.08; width pronotum/head: 1.22; length/width of elytra: 1.62; length elytra/pronotum: 2.68.

Colour (Fig. 3). Rather glossy black, but apical third of the elytra rufous, with the anterior margin of the red part semilunar; lateral margins of the elytra in basal half very narrowly dark reddish translucent. Palpi and antenna dark red, femora and tarsi red, tibiae black. Lower surface of head and thorax black, abdomen contrastingly red.

Head (Fig. 3). Short and wide, moderately depressed. Anterior border gently convex, lateral angle obtusely rounded, laterally slightly projecting, lateral borders distinctly oblique. Clypeal suture not perceptible. Labrum narrow, mostly concealed by the clypeus, apex straight, bisetose. Antennal groove laterally sharply bordered, latero-posteriorly with weakly carinate area. Mental tooth triangular, short, apex acute. Wings of mentum wide, laterally rounded, apex slightly oblique. Glossa wide, tongue-like,

apically convex, ventrally with indistinct keel, at border with c. 10 elongate setae and additional pilosity on upper and lower surfaces and along border. Terminal palpomere of maxillary palpus widened apicad, slightly securiform. Terminal palpomere of labial palpus very wide, markedly securiform. Antenna short, 8th - 9th antennomeres almost 2 × as wide as long. Surface with a shallow sulcus medially of the eye, impilose, with very fine though fairly distinct, isodiametric microreticulation and minute punctures barely recognisable even at high magnification. Ventro-laterally of the eye with few short setae. Suborbital field impunctate and asetose. Gula apparently asetose.

Pronotum (Fig. 3). Narrow, dorsally very convex, base narrow, little narrowed to apex. Apical angle moderately produced, at apex obtusely angulate, somewhat oblique, slightly surpassing the posterior margin of the eye. Apex moderately excised, slightly convex in excision, faintly bordered. Lateral margin very gently convex, in basal half almost straight. Marginal sulcus narrow, slightly widened apicad. Basal angle obtusely angulate, rather rounded at the very tip. Base almost straight, distinctly bordered. Surface near base without transverse impression. Microreticulation extremely fine and very superficial, barely perceptible, punctation very fine, barely recognisable on disc, laterally slightly more distinct, surface impilose, glossy.

Elytra (Fig. 3). Narrow and elongate, dorsally very convex, barely narrowed to apex, sides straight. Apex rather wide, oblique and slightly convex, apical angles rounded off. Humerus rounded, basal margin short, slightly oblique. Marginal channel narrow, but visible even near apex. Basal border almost complete, ending very close to suture. Lateral border asetose except for a few stiff setae at humerus. Series of umbilical pores consisting of 6 regularly set pores behind humerus and a single pore in apical half. Setae short. Striae not recognisable. Scutellary pore and stria absent. Microreticulation extremely fine and superficial, isodiametric, only remnants visible at very high magnification, punctation on disc very fine, rather dense, laterally more distinct and slightly coarser, surface impilose, very glossy.

Lower surface. Prosternal process rather short, fairly wide, straight, gently convex, apex wide and rather short, margin depressed, slightly convex, feebly setose. Metepisternum rather elongate, > 2 x as long as wide. At least the preapical abdominal sternum with an ambulatory seta on either side. Sternum VI without longer setae along apical border. Lower surface with sparse, but rather elongate, erect to slightly declined pilosity.

Legs. Rather short, 1st tarsomere of protarsus slightly wider than long, tibial groove of profemur deep, anterior plate widely overlapping the groove for apical third, posterior border of groove sharp. Femur wide. Metatibia medium-sized, c. 4.5 x as long as wide, 1st tarsomere of metatarsus slightly > 1.5 x as long as wide. Squamosity of male protarsus unknown.

Male genitalia. Unknown.

Female gonocoxites (Fig. 7). Gonocoxite rather narrow, with wide, convex apex; with 4 elongate and one shorter apical setae. Lateral plate fairly elongate, at the rounded medio-apical angle with 3 elongate apical setae.

Vivipary. Not recorded.

Variation. Unknown.

Distribution. South-eastern Queensland. Known only from type locality which is just south of the town of Canungra.

Collecting circumstances. The holotype was collected by pyrethrum fogging of the bark of rain forest trees.

Relationships. The species is rather similar in appearance to *A. semilunatus* Baehr, 1997, but the relations to that species are uncertain, as long as the male genitalia of both species are not known.

KEYS

The species are introduced into the respective keys in the revisions (Baehr 1992, 1997). Figures in the revision are cited as Ba92 fig. and Ba97 fig.

Sphallomorpha cognata

In the key to the species of the genus *Sphallomorpha* (Baehr 1992) couplet 71 is reached which must be changed as following:

71. Large, wide species (> 9.0 mm). Aedeagus laterally of apex markedly sinuate (Fig. 4; Ba92 fig. 98k). 71a
– Smaller, less wide species (< 8.5 mm). Aedeagus either compact with wide, semicircular apex (Ba92 fig. 97k), or with rather acute apex which is laterally not markedly sinuate (Ba92 figs 99k, 100k). . . 72

71a Elytral intervals moderately but distinctly raised. Posterior marginal seta of pronotum present. Elytra with 19-20 marginal setae. Apex of aedeagus with two finely denticulate folds; lateral margins of aedeagus not pilose (Ba92 fig. 98k). Eastern QLD. . . . . .*politoides* Baehr, 1992
– Elytral intervals very little raised. Posterior marginal seta of pronotum absent. Elytra with 13-14 marginal setae. Apex of aedeagus with two not denticulate rods; lateral margins of aedeagus shortly pilose (Fig. 4). South-eastern QLD . . . . . *cognata* sp. nov.

Adelotopus moffatti

In the key to the species of the genus *Adelotopus* (Baehr 1997) couplet 72 is reached which must be changed as following:

72 Body narrower, generally with longer elytra, ratio l/w of elytra 1.39-1.53. Ratio width base/apex of pronotum < 1.70. When pronotum wide, then elytral striae at apex not distinctly rasp-like punctate (at 40x). . . 73.
– Body wider, generally with shorter elytra, ratio l/w of elytra < 1.38. Ratio width base/apex of pronotum > 1.76. When pronotum rather narrow, then elytral striae at apex distinctly rasp-like punctuate (at 40x) . . 74

73 Elytra generally slightly shorter, ratio l/w 1.38-1.48 and ratio l/w of pronotum < 1.85 and parameres convexly triamgular, with angulate apex (Ba97 figs 129i,k). e.SA, VIC, ACT. NSW, e.QLD; ?TAS . . . . . *politus* Castelnau, 1867
– Elytra generally slightly longer, ratio l/w 1.46-1.53; either ratio l/w of pronotum < 1.85 and parameres less triangular, with rather convex apex (Ba97 figs 132i,k) **or** ratio l/w of pronotum > 1.85 and parameres convexly triangular, with angulate apex (Fig. 5). ne.NSW, se. and c. QLD 73a

73a Pronotum less wide, ratio l/w < 1.85; parameres less triangular, with rather convex apex (Ba97 Figs 132i,k). ne.NSW, se.QLD . . . . . *doyeni* Baehr, 1997
– Pronotum wider, ratio l/w > 1.85; parameres convexly triangular, with angulate apex (Fig. 5). c.QLD. . . . . *moffatti* sp. nov.

74 As in Baehr 1997.

Adelotopus leviusculus

In the key to the species of the genus *Adelotopus* (Baehr 1997) couplet 40 is reached which must be changed as following:

40 Red apical part of the elytra anteriorly straight. Gonocoxite narrow, apical part parallel (Ba97 fig. 327). ne.QLD . . . . . *sparsepunctatus* Baehr, 1997
– Red apical part of the elytra anteriorly concave. Gonocoxite wider, apical part triangular or convex (Fig. 7; Ba97 figs 324, 325, 328). Distribution different . . . . . 41.

41 Elytra shorter, ratio l/w 1.55. Gonocoxite very wide, apex obliquely convex (Ba97 fig. 141l). Aedeagus unknown. Distribution unknown. . . . . *semilunatus* Baehr, 1997
– Elytra longer, ratio l/w > 1.60. Gonocoxite narrower, apex differently shaped (Fig. 7; (Ba97 figs 137l, 138l) . . . . . 41a.

41a Body size smaller, length 5.35 mm. Pronotum narrower, ratio w/l 1.17, little narrowed apicad (Fig. 3). se. QLD . . . . . .*leviusculus* sp. nov.
– Body size larger, length > 6.0 mm. Pronotum wider, ratio w/l > 1.55, markedly narrowed apicad . . . . . 42.

42 As in Baehr 1997.

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A new genus and two new species of land snail from geographically remote lithorefugial habitats in Queensland including a remarkable range extension for *Quistrachia* Iredale, 1939 (Gastropoda: Eupulmonata: Camaenidae)

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ABSTRACT

One new genus and two new species of camaenid are described from geographically remote lithorefugial habitats in Queensland. The two habitats have contrasting environments characterised by radically different geology, climate and vegetation. *Lorelliana* gen. nov. is introduced to accommodate *L. hoskini* sp. nov. from the high rainfall, rainforest peppered, granitic lithorefugia of Cape Melville, Cape York Peninsula. *Quistrachia nevbrownlowi* sp. nov. is described from the quartzic limestone refugia of the low rainfall, often drought affected, spinifex grassland of Mt Unbunmaroo (= Black Mountain), south-western Queensland. The survival of each species is discussed in relation to the significance of lithorefugia as habitat for land snails in otherwise snail-hostile environments. ❐ *new genus, new species, Gastropoda, Camaenidae, lithorefugia.*

The Camaenidae is a family of land snails that is particularly diverse in the rainforests of eastern Queensland (Stanisic *et al.* 2010). Long recognised as a late Miocene invader from land masses to Australia's north (Bishop 1981; Solem 1992, 1997), the family has managed to radiate extensively in many areas of Australia. In eastern Australia camaenids are prominent snails in both the wetter humid coastal rainforests and the drier subcoastal and inland rainforests. Relatively few camaenids have made the transition to much drier eucalypt forests and woodland in eastern Australia. Greatest diversity occurs in the subtropical and tropical rainforests that range from central New South Wales to the Wet Tropics of northern Queensland. The two Queensland camaenids described herein occur in rocky habitats in geographically remote environments characterised by differing lithologies, vegetation and rainfall. In each case, adapting to life in lithorefugia has been critical to their survival.

Lorelliana hoskini gen. et sp. nov. occurs among the boulder strewn, rainforest habitats of the Melville Range, Cape York Peninsula. Cape York Peninsula is a bioregion characterised by extensive savanna woodlands. Humid tropical rainforest occurs mainly in the eastern ranges (McIlwraith Range, Iron Range), along some water courses (e.g. Wenlock River, Jardine River) and at the tip of Cape York (Lockerbie Scrub). Elsewhere along the east coast tropical rainforest occurs in remnant scattered pockets in gully or rocky headland environments such as those at Cape Melville. This area is subject to high annual rainfall which combined with the moisture retaining qualities of the granitic lithorefugia enables it to support tropical rainforest communities. Camaenid

diversity on Cape York reflects the pattern of scattered, relatively small rainforest patches and consequently is much lower than it is in the vast rainforest massif of the Wet Tropics…but local endemism is high. *L. hoskini* sp. nov. is one such endemic species.

At the other end of the climatic spectrum *Quistrachia nevbrownlowi* sp. nov. is described from the dry spinifex grasslands of Mt Unbunmaroo (= Black Mountain), via Boulia, south-western Queensland (SWQ). Here the annual rainfall is consistently very low in a pattern often compounded by extensive year-long droughts. *Q. nevbrownlowi* sp. nov. is shown to belong to a genus of land snail otherwise only present in the Pilbara and southern Kimberley, north-western Western Australia. This extraordinary disjunct distribution is unique to the family and is probably an artefact of a much wider generic distribution in the past that has been splintered by the continued aridification of the continent since the Miocene. The quartzic lithorefugium of Black Mountain would have been critical in the survival of the species in the face of this gradual but dramatic climatic shift.

MATERIAL AND METHODS

Material used in this study is held in the collections of the Queensland Museum (QMMO). Studies of shell characters were carried out on specimens in the museum's dry collection (RC) and anatomical studies were based on ethanol preserved samples (SC). Measurements of shell characters (height, diameter, umbilical width) were made using callipers with a precision of 0.01 mm. Whorl counts were made to the nearest 1/8 whorl. Several representatives of the species from their respective type localities were dissected and studied using a WILD M5 stereo microscope with drawing apparatus in order to confirm stability of reproductive structures.

SYSTEMATICS

Infraorder EUPULMONATA

Superfamily HELICOIDEA

Family CAMAENIDAE

Genus *Lorelliana* gen. nov.

Etymology. Named for Lorelle Holcroft, former deputy principal and teacher at Queensland's Samford State School in recognition of her efforts in science education.

Diagnosis. Shell medium sized, creamy yellow with reddish brown subsutural and peripheral spiral bands, acutely depressedly trochoidal with a sharply carinate periphery; protoconch smooth, teleoconch mainly smooth with vague radial growth ridges, base shiny; aperture ovately lunate, lip reflected; umbilicus small but open. Penis sheath present, thick-walled. Penis sub-cylindrical, internally with a dense pattern of rhomboidal pilasters, without verge or prominent pilaster. Epiphallus long with slender ascending arm, descending arm thick, folded within penial sheath, entering penis through a simple pore; epiphallic caecum present.

Type species. *Lorelliana hoskini* sp. nov.-herein designated.

Lorelliana hoskini sp. nov.
(Figs 1, 2A-C, 3)

Etymology. Named for Conrad Hoskin, in recognition of his work on Cape Melville boulder field vertebrates.

Preferred common name. Cape Melville Talus-snail.

Material examined. Holotype. QMMO85061, shell RC/animal SC, Cape Melville, Melville Range, FNQ, (14°17′55″S, 144°28′50″E), rainforest on rocky talus, on granite boulders, 10.ii.2013, coll. C. Hoskin, K. Aland. Height of shell 10.46 mm, diameter 15.84 mm, umbilical width 2.29 mm, H/D = 0.66, D/U = 5.68, number of whorls 4.125.

Paratypes. QMMO80774, shell RC/animal SC, same data as holotype; QMMO85060, 6RC, Cape Melville, Melville Range, FNQ, (14°17′55″S, 144°28′50″E), rainforest on rocky talus, in litter, 15.xii.2013, coll. C. Hoskin, H. Hines.

Diagnosis. As for genus.

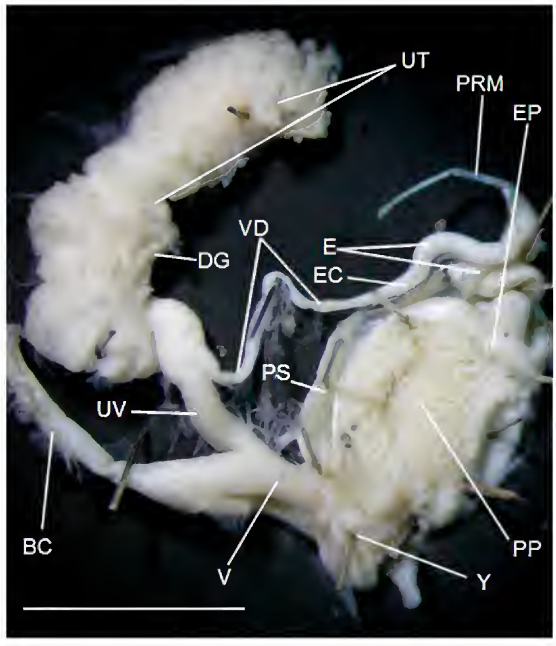

FIG. 1. *Lorelliana hoskini* gen. et sp. nov. QMMO85061, holotype. Genitalia. Scale line = 10 mm.

Description. Shell medium sized, creamy yellow with reddish brown subsutural and peripheral spiral bands, acutely depressedly trochoidal with a sharply carinate periphery, whorls 4.125-4.75 (mean 4.5), the last descending slightly in front; spire slightly elevated. Height of shell 7.67-8.44 mm (mean 8.11 mm), diameter of shell 17.34-18.80 mm (mean 18.10 mm), H/D = 0.43-0.47 (mean 0.45). Protoconch of 1¾ whorls, shiny, teleoconch mainly smooth with vague radial growth ridges, base shiny. Aperture ovately lunate, lip reflected, white; umbilicus small but open, umbilical width 2.03-2.66 mm (mean 2.37 mm), D/U = 6.81-8.54 (mean 7.74). Based on eight measured shells (QMMO80774, QMMO85060, QMMO85061).

Genitalia. Penis sheath (PS) present, thick-walled. Penis (P) sub-cylindrical, internally with a dense pattern of rhomboidal pilasters (PP), without verge or prominent main pilaster. Epiphallus (E) long with slender ascending arm, descending arm thick, folded within penial sheath, entering penis through a simple pore (EP); epiphallic caecum (EC) present. Vas deferens (VD) short. Penial retractor muscle (PRM) inserted on the epiphallus at the point of reflexion. Vagina (V) short, less than half length of penis, internally with longitudinal thickenings. Atrium (Y) simple. Free oviduct (UV) almost equal in length to vagina; bursa copulatrix (not figured) with a relatively wide stalk (BC) located at the base of the albumen gland; prostate (DG) and uterus (UT) without unusual features. Albumen gland, hermaphroditic duct and ovotestes not illustrated. Based on two dissected adults (QMMO80774, QMMO85061).

Animal. Animal (Fig. 3) orange with orange foot, black head and neck, upper and lower tentacles orange. Pallial region with black pallial collar and two black stripes running rearwards and located on either side of the pallial roof. Head wart present.

Habitat and ecology. Scattered patches of rainforest on granite talus; living among granite boulders.

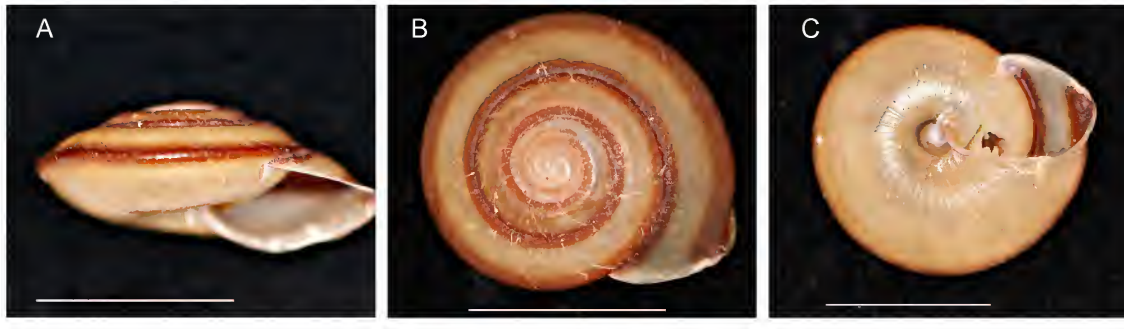

FIG. 2. *Lorelliana hoskini* gen. et sp. nov. QMMO85061, holotype. Shell views. **A**, apertural; **B**, dorsal; **C**, ventral. Scale lines = 10 mm.

FIG. 3. *Lorelliana hoskini* gen. et sp. nov. Live animal.

Distribution. Known only from the type locality.

Remarks. *Lorelliana hoskini* sp. nov. is endemic to the Melville Range boulder fields (Fig. 4) and can be readily distinguished by the combination of sharply carinate, very depressed, trochoidal shell and the orange animal with orange tentacles and black head. The relationships of the species are yet to be determined however, the short penis with a thick sheath, internal wall sculpture of dense rhomboidal pilasters, no verge and no main pilaster combined with an epiphallus which is partially folded within the penial sheath are a combination of anatomical characters which separate this species from all other Cape York Peninsula camaenids thus far dissected (Stanisic, unpubl.).

Interestingly the shell of *L. hoskini* bears an uncanny resemblance to that of *Trochomorpha melvillensis* Solem, 1989 (Family Trochomorphidae) which curiously comes from a somewhat similarly named locality in Melville Island (Tiwi Islands), Northern Territory. However, the superficial conchological resemblance between the two species is not reflected in vastly different shell sculpture and the contrasting anatomical details (Solem 1989).

Genus *Quistrachia* Iredale, 1939

Diagnosis. See Solem (1997).

Type species. *Trachia monogramma* Ancey, 1898-by original designation.

Quistrachia nevbrownlowi sp. nov.
(Figs 5A, B; 6A-C)

Etymology. Named for Neville Brownlow, Director of Earthborn Australia Pty Ltd, in recognition of his efforts in organic waste recycling.

Preferred common name. Boulia Globular Snail.

Material examined. Holotype. QMMO85063, shell RC/animal SC, Boulia, c. 50 km NE at Black Mt, SWQ, (22°33'03"S, 140°13'22"E), along creek in flood debris, 20.xi.2002, coll. R. Crookshanks. Height of shell 10.46 mm, diameter 15.84 mm, umbilical width 2.29 mm, H/D = 0.66, D/U = 5.68, number of whorls 4.625.

Paratypes. QMMO71806, 3SC, same data as holotype; QMMO71805, 4 SC, Boulia, c. 50 km NE at Black Mt, SWQ, (22°36'10"S, 140°13'32"E), along creek in flood debris, 20.xi.2002, coll. R. Crookshanks; QMMO72256, 6SC, Boulia, c. 50 km NE at Black Mt, SWQ, (22°38'27"S, 140°16'14"E), along creek in flood debris, 20.xi.2002, coll. R. Crookshanks; QMMO71807, 3SC/1RC, Boulia, c. 50 km NE at Black Mt, SWQ, (22°30'00"S, 140°16'30"E), along dry gully under dead spinifex, 20.xi.2002, coll. R. Crookshanks; QMMO4995, 50+ RC, AMSC.517369, 6RC; WAMS70841, 6RC; Black Mt, Warenda Station, c. 60 km NE Boulia, gibber and spinifex plain/limestone, on ground, alt. c. 180 m, viii.1971, coll. A. Hiller, M. Wade.

Other material. QMMO15053, 7SC, Black Mt, NE Boulia, WCQ, limestone area, viii.1984, coll. A. Rozefelds; QMMO85064, 4RC, locality given only as Queensland (= Black Mountain area, via Boulia), SWQ, 1975, coll. M. A. Archer.

Diagnosis. Shell medium-sized, with reddish brown suffusion on upper whorl surface extending below whorl periphery and a darker, narrow subsutural band and less prominent peripheral band, base white; helicoid with an elevated spire and rounded whorls; teleoconch sculpture of closely spaced, anastomosing radial ridges; aperture roundly lunate, lip white, expanded and reflected; umbilicus narrowly open. Penis with a thick sheath, internally with a main long, bifurcated pilaster, penis wall with

FIG. 4. Cape Melville boulders and rainforest. Image: Conrad Hoskin.

a series of longitudinally arranged diamond-shaped pustules merging into longitudinal pilasters basally. Vas deferens entering penis sheath basally and ascending almost entire length of penis, epiphallus short, entering penis apically through a simple pore; bursa copulatrix with a short stalk and expanded head located at the base of the prostate-uterus.

Description. Shell medium-sized, with reddish brown suffusion on upper whorl surface extending below whorl periphery and a darker, narrow reddish brown subsutural band and less prominent reddish brown peripheral band, base white; helicoid with an elevated spire and 4.125-4.625 (mean 4.5-) rounded whorls, the last descending slowly in front; spire moderately elevated. Height of shell 7.96-11.43 mm (mean 9.62 mm), diameter 13.15-16.94 mm (mean 14.72 mm), H/D = 0.58-0.69 (mean 0.65). Protoconch of 1½ whorls sculptured with irregular radial ridges, teleoconch sculpture of closely spaced, anastomosing radial ridges extending onto base. Aperture roundly lunate, lip white, expanded and reflected; umbilicus narrowly open, umbilical width 2.10-2.78 mm (mean 2.46 mm), D/U = 4.82-7.17 (mean 6.03). Based on 22 measured adults (QMMO4995, QMMO71807, QMMO85063).

Genitalia. Penis (P) with a thick sheath (PS), internally with main pilaster bifurcated (PPM), penis wall with a series of longitudinally arranged diamond-shaped pustules (PP) merging into longitudinal pilasters basally. Vas deferens (VD) entering penis sheath basally (VDE) and ascending almost entire length of penis. Epiphallus (E) short, entering penis

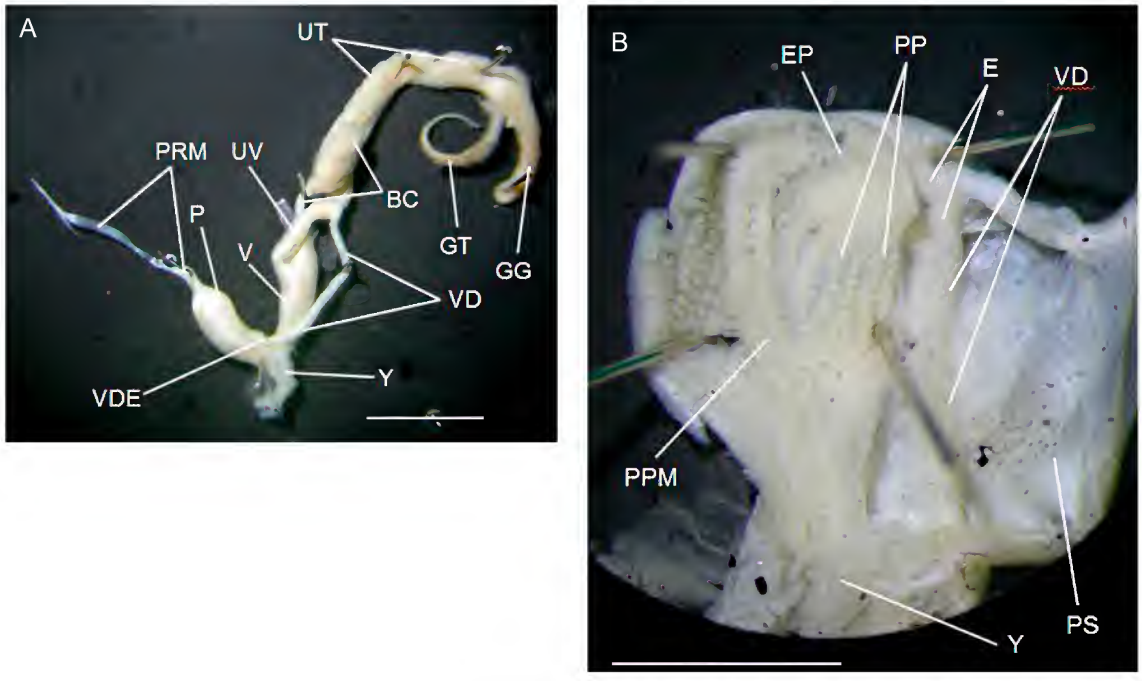

FIG. 5. *Quistrachia nevbrownlowi* sp. nov. QMMO71807, paratype. **A**, genitalia. Scale lines = 5 mm; **B**, penial complex. Scale lines = 2.5 mm.

apically through a simple pore (EP). Vagina (V) equal in length to the penis, internally with longitudinal thickenings, free oviduct (UV) relatively long; bursa copulatrix (BC) short with an expanded head located at the base of the prostate-uterus; prostate (DG) and uterus (UT) without unusual features. Albumen gland (GG) slender, hermaphroditic (GD) duct typical.

Animal. Preserved animal with light-brown body, head region slightly darker. Head wart absent.

Habitat and ecology. Spinifex on quartzic limestone; living under spinifex, rocks and scattered debris.

Distribution. Known only from Mt Unbunmaroo (= Black Mountain), NE Boulia, SWQ.

Remarks. *Quistrachia nevbrownlowi* sp. nov. has only been recorded in the vicinity of Mt Unbunmaroo (= Black Mountain), via Boulia, SWQ. The habitat is one of quartzic limestone

FIG. 6. *Quistrachia nevbrownlowi* sp. nov. QMMO85063, holotype. Shell views. **A**, apertural; **B**, dorsal; **C**, ventral. Scale lines = 10 mm.

TABLE 1. Local variation in shells of *Lorelliana hoskini* sp. nov. and *Quistrachia nevbrownlowi* sp. nov.

Taxon	N	Diameter (mm)	Height (mm)	Umbilical width (mm)	H/D ratio	D/U ratio	Number of whorls
L. hoskini sp. nov.							
QMMO85061 holotype	1	17.34	7.67	2.03	0.44	8.54	4.125
QMMO80774 paratype	1	18.80	8.44	2.36	0.45	7.97	4.375
QMMO85060 paratypes	6	17.52-18.80	7.69-8.36	2.23-2.66	0.43-0.47	6.81-8.43	4.5-4.75
Q. nevbrownlowi sp. nov.							
QMMO85063 holotype	1	16.59	10.65	2.79	0.64	5.95	4.625
QMMO4995 paratypes	20	13.15-16.94	7.96-11.45	2.10-2.78	0.58-0.69	4.82-7.17	4.125-4.625
QMMO71807 paratype	1	15.84	10.46	2.59	0.66	6.12	4.5

and spinifex grassland (Fig. 7). *Q. nevbrownlowi* is the sole outlier of a genus whose main mass of species (9) is located in the Pilbara, Dampierland and southern Kimberley of north-western Western Australia. The basal entrance of the vas deferens into the penial sheath, poorly defined epiphallus, bifurcated main penial pilaster and short bursa copulatrix are all features which clearly place the species in the otherwise Western Australian genus. The genital features most closely ally *Q. nevbrownlowi* to the Pilbara species *Q. legendrei* Solem, 1997.

Quistrachia nevbrownlowi was noted by Solem (1997:1876-1877) in his revision of *Quistrachia* but never described.

DISCUSSION

The present study highlights the importance of lithorefugia for the survival of land snails in two contrasting Queensland environments. The granite boulder fields of the Melville Range, Cape York Peninsula is in an area of relatively high annual rainfall (average annual rainfall > 1500 mm). The quartzic limestones of Mt Unbunmaroo (= Black Mountain) on the other hand have very low rainfall (mean < 250 mm per annum) with sporadic episodes of multi-year droughts. In the case of both *Lorelliana hoskini* sp. nov. and *Quistrachia nevbrownlowi* sp nov. these land snails have displayed resilience in the face of climatically induced, snail-hostile environmental change.

Lorelliana hoskini sp. nov. lives among the granite talus of Cape Melville in an area where rainforest has contracted and now occurs in gullies and on elevated plateaux within the boulder fields of the greater Melville Range, Cape York Peninsula (Fig. 8). Rainforest in eastern Australia receded into mountain top refugia and along moist drainage lines from the mid-Miocene onwards, and with greater amplitude and rapidity during the Quaternary (Galloway & Kemp 1981). Deeply layered rocky outcrops such as those in the Melville Range would have provided persistent moist and cool microhabitats for mesic organisms such as land snails (Couper & Hoskin 2008). Having a shell for protection and one which is designed for life in crevices (flattened) combined with a nocturnal habit would have pre-adapted the species for survival in such a specialised environment. Persistently high rainfall and shelter from fire would also have been major contributing factors. The area is already remarkable for the number of endemic vertebrate species (three frogs, two skinks and one gecko) all of which have connections with the rainforests of the Wet Tropics further south (Hoskin & Couper 2013; Hoskin 2013a, b, 2014).

FIG. 7. The spinifex covered terrain around Mount Unbunmaroo (= Black Mountain), via Boulia, SWQ. Image: Graham Harrington.

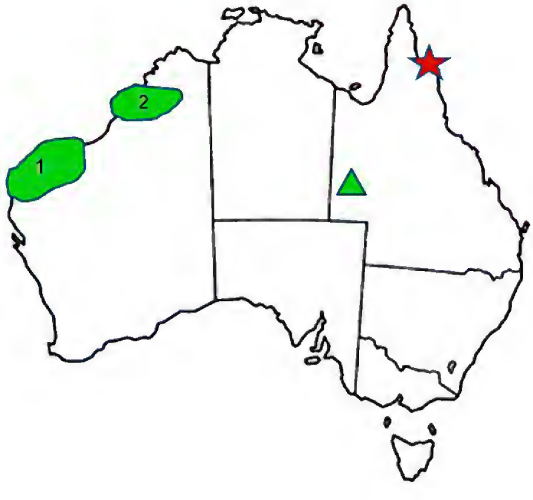

FIG. 8. Distribution map. *Lorelliana hoskini* gen. et sp. nov. (star): Cape Melville, north Queensland; *Quistrachia nevbrownlowi* sp. nov. (triangle): Mt Unbunmaroo, SWQ; Other *Quistrachia* spp., north-western Western Australia: 1, Pilbara; 2, Dampierland and southern Kimberley.

L. hoskini is the first endemic invertebrate thus far recorded from the locality. Its relationships are unknown at this time but may also lie within the Wet Tropics where much of the land snail fauna has yet to be collected let alone described.

Quistrachia nevbrownlowi sp. nov. lives among the limestone and spinifex of the Mt Unbunmaroo (= Black Mountain) area, via Boulia, SWQ. However, its nearest relatives are almost 2000 km away on the western edge of the continent, usually in the rocky talus strewn spinifex grasslands of the Pilbara and Kimberley of north-western Western Australia (Fig. 8). While some dry adapted pupillids bridge this geographic gap (*Glyptopupoides egregia*, *Gastrocopta* spp.) the distribution pattern is quite unusual in the context of the Camaenidae. There are camaenid genera such as *Torresitrachia* and *Xanthomelon* with so-called trans-Australian distributions (Solem 1979), but the range extension of a camaenid genus from its core in the Pilbara-Kimberley to a disjunct species in south-western Queensland, without any intervening congeners, is somewhat remarkable.

The extraordinary range disjunction between *Q. nevbrownlowi* and the main mass of *Quistrachia* species implies that there was once some historical connection of *Quistrachia* habitat between the two regions. It is reasonable to speculate that intervening species would have become extinct along with this historical habitat through climatic attrition in the face of widespread continental aridification. The onset of aridity was accompanied by extensive desertification in central areas of the continent whereby sand dunes covered much of the region. Survival of present day *Quistrachia* species relied on their ability to show resilience in the face of this aridification and adapt to life in scattered rock piles throughout the historical range. The availability of moisture and shelter sites among the rocky talus and the role of rock outcrops in excluding fire are all key attributes beneficial for the continued survival of land snails. That the current Western Australian species now live under rocks and litter among rock outcrops in the climatically challenging Pilbara and Kimberley is practical evidence for such a proposition. In an area of western Queensland that also endures unforgiving climatic conditions the presence of the limestone lithorefugium that is Black Mountain probably played a major role in the survival of *Q. nevbrownlowi*.

In conclusion, it should be added that this study once again underscores the part that land snails (and other invertebrates) can play in identifying places of environmental significance. These organisms are too often ignored in environmental survey and assessment. Yet they have the innate ability to identify special habitats in their roles as both environmental indicators and biodiversity predictors, in particular the moisture loving land snails.

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Typeset at the Queensland Museum

The new endemic Australian genus *Nosterella* and a review of *Nostera* (Araneae: Zodariidae), including eight new species

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ABSTRACT

A new genus is created to include *Nosterella nadgee* (Jocqué, 1995), and five new species: *Nosterella cavicola, Nosterella christineae, Nosterella diabolica, Nosterella fitzgibboni, Nosterella pollardi*. Four species of the ant-eating spider genus *Nostera* Jocqué including three new species are described: *Nostera lynx* Jocqué, 1991, *Nostera geoffgarretti, Nostera spinata, Nostera trifurcata*. An identification key is provided for both genera. ❐ *Taxonomy, new genus, new species, ant-eating spiders, Australia.*

Like many other spider families, the Zodariidae has undergone thorough revision in the last decade. A revision of the family at genus level (Jocqué 1991) was followed by many generic revisions (e.g. Baehr & Jocqué 1996, 2001, 2002; Baehr 2004a, 2004b). However, it has become clear that the update of these large families at the level of the genera could not be done in a few efforts due to the lack of sufficient representatives in some of these taxa. For example the Afrotropical genus *Systenoplacis* Simon, 1907, originally described from juveniles, (Jocqué 1991) got synonymized with *Capheris* Simon, 1893. In a later study (Jocqué 2005), the former genus was revalidated because the study of adult specimens clearly showed that the speciose *Systenoplacis,* was sufficiently different to *Capheris*.

Something similar occured to *Nostera* Jocqué, 1991. The genus was initially monotypic as its type species, *Nostera lynx,* did not fit in any of the genera that had been described until then. A single species does not provide an idea of the variation within a genus. The definition of the genus had to be expanded substantially (Jocqué 1995) when the second species was added to *Nostera, N. nadgee* Jocqué, 1995. The present study based on many more species shows that *N. lynx* and *N. nadgee* do not belong in the same genus. We therefore create a new genus *Nosterella*.

MATERIAL AND METHODS

The spiders examined for this study included unidentified *Nostera* specimens from the collection of the Queensland Museum. The study also included one new species from New South Wales which will be lodged in the Australian Museum, Sydney (AM). The remaining specimens will remain in the Queensland Museum's collection (QM).

One of the eight new species was collected on the Australian Biological Resources Study (ABRS) Bush Blitz expedition to Carnarvon Station Queensland (conducted by the Queensland Museum in October 2014). Latitudes, longitudes and elevation were determined by GPS. Because older locality labels do not often provide accurate geographical coordinates, latitudes and longitudes from Google Earth have been used in cases where they were not mentioned.

Specimens were examined using a Leica MZ16A microscope. Images were produced using a Leica DFC 500 with AutoMontage Pro Version 5.2. Epigynes were placed for a few hours in a Pancreatin solution as described in Álvarez-Padilla & Hormiga (2007). After the enzymatic digestion, the epigynes were transferred to distilled water and then to 70% ethanol.

All measurements are in millimetres.

Abbreviations used in the text are as follows: ALE anterior lateral eyes; ALS anterior lateral spinnerets; AME anterior median eyes; C conductor; CD copulatory duct; CO copulatory opening; E embolus; FD fertilization duct; LI lateral incision at epigynal fold; MA Median apophysis; MS median septum; PLE posterior lateral eyes; PLS posterior lateral spinnerets; PME posterior median eyes; PMS posterior median spinnerets; RTA retrolateral tibial apophysis; S spermatheca; W window of epigynum. QM Queensland Museum; AM Australian Museum.

SYSTEMATICS

Family *Zodariidae* Thorell, 1881

Subfamily *Storeninae* Simon, 1893

Nostera Jocqué, 1991

Nostera lynx Jocqué, 1991: 72, figs 142–150 (type species by original designation *Nostera lynx* Jocqué).

Diagnosis. *Nostera* and *Nosteralla* share a strongly procurved posterior eye row (Fig. 2B). Males of *Nostera* differ from those of *Nosterella* by having a convex cymbium on both sides (Figs 5A–D), no posterior extension of the tegulum (Figs 5A–D), a membranous conductor and a broad embolus (Figs 5A–D); females differ by having an epigynal window anteriorly whereas females of *Nosterella* have a membranous rectangular epigynal window posteriorly (Fig. 7E).

Key to species of the genus *Nostera*

Females unknown for all species except *N. lynx*

1. Male palpal tibia with large retrolateral protuberance (Figs 2G, 5D) . . . *N. geoffgarretti*
– Palpal tibia without large retrolateral protuberance (Figs 1F, 3F, 4F) 2

2. Embolus trifurcate, tibial apophysis directed outwards (Figs 4F, 5C) . . . . . *N. trifurcata*
– Embolus scoop shaped, tibial apophysis directed distad (Figs 1F, 3F). 3

3. RTA slightly indented, no separate ventral part (Figs 1D, 5A) . . . . . *N. lynx*
– RTA strongly indented, ventral part a strong spine (Figs 3D–F, 5B) . . . . . *N. spinata*

Nostera lynx Jocqué, 1991
(Figs 1 A–F, 5A, 17A)

Nostera lynx Jocqué, 1991: 72, figs 142–150.

Material examined. New South Wales: 1 female (QM S4237), Mt Glennie, 16 km E Woodenbong. 28°23′S, 152°46′E, rainforest 910 m, G. Monteith, D. Yeates, 25 Nov 1982, sieved litter; Queensland: 1 male (QM S12120), Bald Mtn, via Emuvale, 28°43′S, 152°16′E, G. Monteith, 18 Aug–17 Nov 1974, pitfall; 1 male, 1 female (QM S12121), same as previous, 17 Nov–28 Dec 1974, pitfall; 1 female (QM S12190), Beechmont, Rozen's Lookout, 28°08′S, 153°12′E, rainforest 120 m, G. Monteith, 26 Oct–14 Dec 1974, pitfall; 1 female (QM S4395), Binna Burra, 28°12′S, 153°10′E, rainforest 120 m, C. Plowman, 25 Jun 1966, leaf litter; 2 female (QM S4477), same as previous, 27 Mar 1976, leaf litter; 1 female (QM S4476), same as previous, 18 May 1983, leaf litter; 1 female (QM S44569), same as previous, Monteith, Russel, 13 Mar 1997, leaf litter; 1 male (QM S12204), Mt Cainbable, via Lamington NP, 28°14′S, 153°08′E, rainforest 762 m, G. Monteith, 1975–1976, pitfall; 1 female (QM S4437), Lamington Plateau, 28°19′S, 153°04′E, R. Raven, 2 April 1975, pitfall; 1 female (QM S4409), Lamington NP, 28°14′S, 153°15′E, Microphyll fern forest, J. Stanisic, D. Potter, 17 Mar 1981, litter; 1 male (QM S4475), Lamington NP, 28°14′S, 153°15′E, microphyll fern forest, V. Davies, R. Raven, 15 Nov 1977, night coll.; 1 male (QM S81036), Lamington NP, 28°14′S, 153°15′E, site 500D, rainforest, S. Maunsell, 12–21 Oct 2006, pitfall; 1 male (QM S76336), Lamington NP, 28°18′S, 153°12′E, site 700A, rainforest, R. Mendenez, G. Monteith, 21–26 Oct 2006, dung pitfall; 1 male

FIG. 1. *Nostera lynx* Jocqué, 1991, male (QM-S81102): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, male palp, dorsal view; **E**, same, retrolateral view; **F**, same, ventral view. Scale bars: 1.0 mm.

(QM S76369), Lamington NP, 28°14'S, 153°37'E, site 300A, rainforest, R. Mendenez, G. Monteith, 21 – 26 Oct 2006, dung pitfall; 1 male (QM S81102, image, drawing), Lamington NP, 28°15'S, 153°13'E, site 300C, rainforest, K. Staunton, 11 – 21 Oct 2006, pitfall; 2 females (QM S811117), Lamington NP, 28°20'S, 153°12'E, site 700D, rainforest, K. Staunton, 11 – 20 Oct 2006, pitfall; 11 males, 1 female (QM S25737), Mt Tamborine, 27°56'S, 153°12'E, G. Monteith, Dec 1978 – Jan 1979, pitfall; 1 male (QM S12138), Mt Tamborine, Palm Grove, 27°56'S, 153°12'E, G. Monteith, 26 Oct – 14 Dec 1974, pitfall; 1 female (QM S12211), Teviot Falls via Boonah, 28°13'S, 152°28'E, rainforest 820 m, G. Monteith, 22 Feb – 8 May 1976, pitfall; 1 female (QM S12128), The Head via Killarney, 28°23'S, 152°19'E, 760 m, G. Monteith, 18 Aug – 17 Nov 1974, pitfall; 1 male (QM S12125), same as previous; 1 male (QM S12167), same as previous 17 Nov – 27 Dec 1974; 1 female (QM S12194), Toonumbar SF, 28°27'S, 152°50'E, rainforest 610 m, G. Monteith, 1974 – 1975; 1 male (QM S12173), Sarabah NP, via Canungra, 28°04'S, 153°07'E, rainforest 120 m, G. Monteith, 13 Aug – 2 Dec 1977.

Distribution. This species is known from rainforest in south-east Queensland and northern New South Wales (Fig. 17A).

Nostera geoffgarretti sp. nov.
(Figs 2 A–G, 5D, 17 A)

Material examined. MALE HOLOTYPE (QM S96349), from Queensland, Mt Elliot, 19°29'S, 146°58'E, A. Graham, 13 Dec 1990; 1 male (QM S18163), same as previous; 1 male (QM S12261), Mt Elliot, 19°29'S, 146°58'E,upper north crest, 1000 m, G. Monteith, G. Thompson, S. Hamlet, 3 – 5 Dec 1996, pitfall.

Etymology. The specific name is a patronym in honour of Dr Geoff Garrett former Chief Scientist of Queensland. Dr Garrett quoted Henry Ford, at the Peter Doherty Awards for Excellence in Science and Science Education in 2011: "*Enthusiasm is the real secret of success. You can do anything if you have enthusiasm. Enthusiasm is the yeast that makes sure hope rises to the stars. Enthusiasm is a sparkling energy to execute your ideas. There is no accomplishment without it.*" These new species would not have been described without the sparkling energy of our enthusiasm for discovering nature.

Diagnosis. The males of *Nostera geoffgarretti* can be separated from males of all other *Nostera* species by the palpal tibia with a large retrobasal protuberance (Figs 2G, 5D).

Description. Male (Holotype, QM S96349). Total length 8.31. Prosoma 4.70 long, 3.12 wide, pl/pw 1.50; sternum 2.02 long, 1.61 wide, sl/sw 1.25; opisthosoma 3.61 long, 2.33 wide. Eyes, both eye rows strongly procurved, ALE largest; ALE 0.17; AME 0.13; PLE 0.16; PME 0.14; ALE–ALE 0.41; ALE–AME 0.13; AME-AME 0.02; ALE-PLE 0.05; PLE-PME 0.18; PME-PME 0.09. Clypeus 0.50 high. Prosoma orange brown, oval, reticulated, posteriorly straight, sides rebordered, fovea short. Chelicerae orange brown; paturon twice as long as wide with lateral condyles. Endites, labium and sternum orange; opisthosoma dark brown with five pairs of pale spots dorsally enclosing four pale transverse bands; venter pale with two triangular dark brown stripes medially and one longitudinal pair of stripes laterally. Legs light orange brown.

Male palp (Figs 2 E – G, 5D): Cymbium oval, longer than wide, covered with black setae and 7 thick spines in distal third; tegulum oval, conductor membranous originating prolaterally, broad, with hood-like distal part; sperm duct strongly s-shaped; embolus straight, finger-shaped; tibia with large retrobasal protuberance, retrolateral tibial apophysis short, conical.

Female unknown.

Distribution. Known only from Mt Elliot in northern Queensland (Fig. 17A).

Nostera spinata sp. nov.
(Figs 3 A–F, 5B, 17A)

Material examined. MALE HOLOTYPE (QM S96350), from New South Wales, Never Never, Dorrigo, 31°22'S, 152°45'E, G. Monteith, 22 Mar–12 Nov 1980, pitfall; 1 male (QM S4245), same as previous; 1 male (QM S3768), Dorrigo NP, 31°22'S, 152°45'E, rainforest, The Glade, 800 m, G. Monteith, 1980–1981, pitfall; 1 male (QM S4243), Never Never, Dorrigo NP, 31°22'S, 152°45'E, rainforest 700 m, G. Monteith, 12 Dec 1980 –16 Mar 1981, pitfall.

Etymology. The specific name is an adjective referring to the spine-shaped tibial apophysis (Fig. 5B).

Diagnosis. Males of *Nostera spinata* can be separated from males of other *Nostera* species by the pale opisthosoma with dark brown chevrons and a strongly indented retrolateral tibial apophysis with a strong spine at the base (Figs 3D–F, 5B).

Description. Male (Holotype, QM S96350). Total length 4.87. Prosoma 2.66 long, 1.80 wide, pl/

FIG. 2. *Nostera geoffgarretti* sp. nov. male holotype (QM-S96349): **A**, habitus, dorsal view; **B**, chelicerae, frontal view; **C**, habitus, lateral view; **D**, habitus, ventral view; **E**, male palp, dorsal view; **F**, same, retrolateral view; **G**, same, ventral view. Scale bars: 1.0 mm.

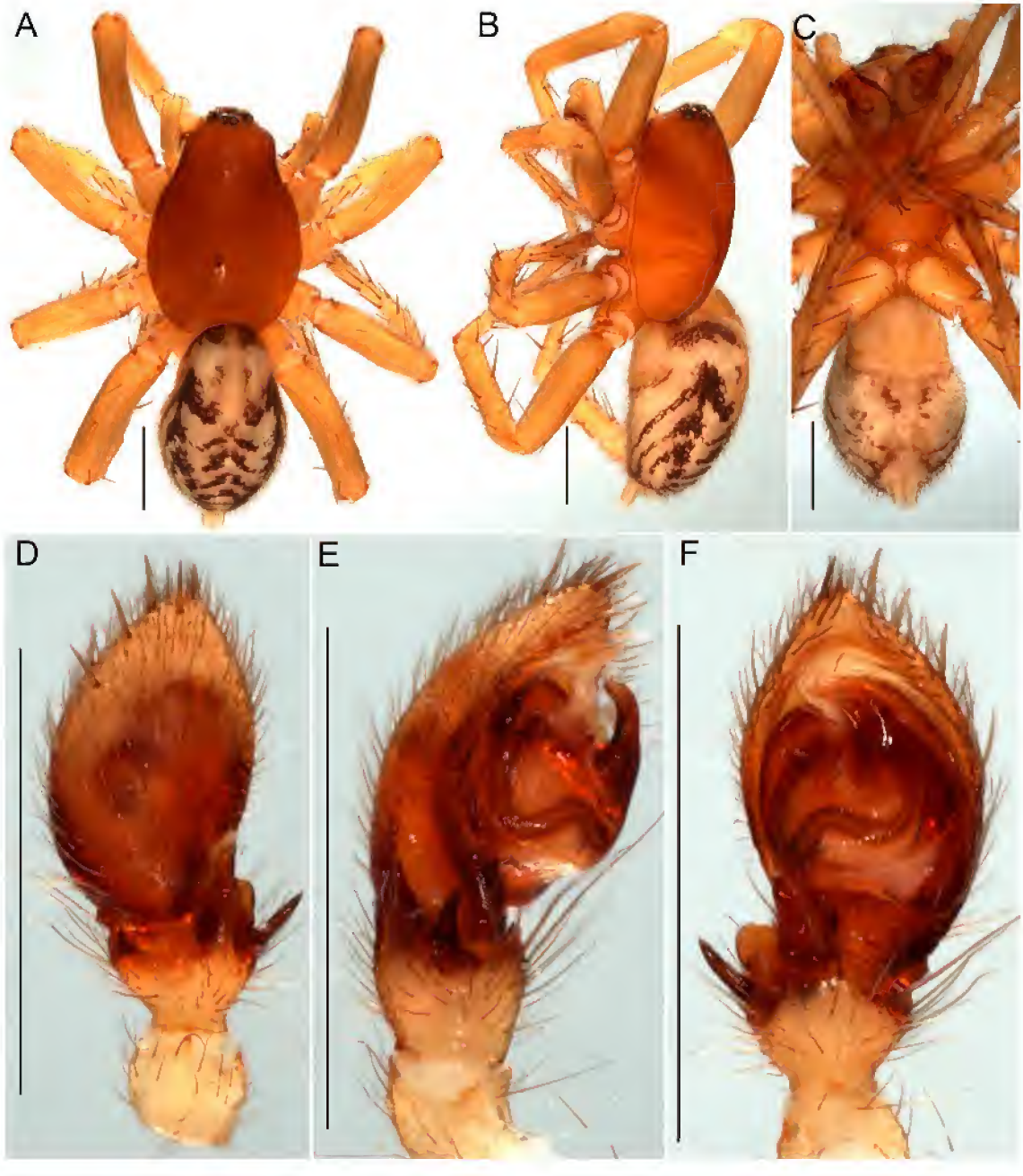

FIG. 3. *Nostera spinata* sp. nov. male holotype (QM-S96350): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, male palp, dorsal view; **E**, same, retrolateral view; **F**, same, ventral view. Scale bars: 1.0 mm.

pw 1.48; sternum 1.15 long, 1.04 wide, sl/sw 1.11; opisthosoma 2.21 long, 1.50 wide. Eyes, both eye rows strongly procurved, ALE largest; ALE 0.13; AME 0.11; PLE 0.12; PME 0.12; ALE-ALE 0.20; ALE-AME 0.05; AME-AME 0.03; ALE-PLE 0.03; PLE-PME 0.11; PME-PME 0.02. Clypeus 0.23 high. Prosoma orange, oval, reticulated, posteriorly straight, sides rebordered, fovea short. Chelicerae orange; paturon twice as long as wide with lateral condyles. Endites, labium and sternum orange, tips of endites and labium pale; opisthosoma pale with dark brown chevrons; venter pale with one pair of dark brown spots. Legs pale orange, femur I slightly darker.

Male palp (Figs 3 D – F, 5B): cymbium oval, longer than wide, covered with black setae and 6 thick spines in distal third; tegulum oval, distally with a spatulate membranous conductor a small S-shaped sclerotized MA and a finger shaped embolus; retrolateral tibial apophyisis strongly indented with a strong spine at the base.

Female unknown.

Distribution. This species is known only from Dorrigo in New South Wales (Fig. 17A).

Nostera trifurcata sp. nov.
(Figs 4 A–F, 5C, 17A)

Material examined. MALE HOLOTYPE (QM S15740), from Queensland, Lake Broadwater via Dalby, 27°21'S, 151°05'E, open forest, V. Davies, M. Bennie, 17 May – 24 Nov 1985, pitfall.

Etymology. The specific name is an adjective referring to the shape of the embolus.

Diagnosis. Males of *Nostera trifurcata* can be separated from males of other *Nostera* species by the large AME, the outward directed retrolateral tibial apophysis and the broad trifurcate embolus (Figs 4 D – F, 5C).

Description. Male (Holotype, QM S15740). Total length 8.24. Prosoma 4.37 long, 3.77 wide, pl/pw 1.58; sternum 1.69 long, 1.59 wide, sl/sw 1.06; opisthosoma 3.86 long, 2.58 wide. Eyes, both eye rows strongly procurved, AME largest; ALE 0.17; AME 0.23; PLE 0.16; PME 0.15; ALE-ALE 0.45; ALE-AME 0.07; AME-AME 0.03; ALE-PLE 0.03; PLE-PME 0.19; PME-PME 0.11. Clypeus 0.50 high. Prosoma orange brown, margin and sides of cephalic area darker, oval, reticulated, posteriorly straight, sides rebordered, fovea short. Chelicerae orange brown; paturon 2.5 times as long as wide with lateral condyles. Endites, labium and sternum orange, tips of endites and labium pale; opisthosoma dark brown with five pairs of small pale spots dorsally, followed by two thin transverse bands, enclosed by a pair of longitudinal pale bands; venter pale. Legs light orange brown, femora slightly darker.

Male palp (Figs 4D–F, 5C): cymbium oval, longer than wide, covered with black setae and 6 thick spines at distal third; tegulum oval, membranous conductor spatulate, MA sclerotized with sickle-shaped tip embolus broad trifurcate originating distally of tegulum; retrolateral tibial apophysis finger-shaped, directed outwards.

Female unknown.

Distribution. This species is known only from the vicinity of Lake Broadwater in southern Queensland. (Fig. 17A).

Nosterella new genus

Type Species. *Nostera nadgee* Jocqué, 1995.

Etymology. The generic name is an arbitrary combination of letters considered feminine in gender.

Diagnosis. Males of this genus can easily be recognised by the concave retrolateral shape of the cymbium (Figs 16 A–F), the posterior tegular extension reaching at least as far as the centre of the tibia, conductor and sclerotized median apophysis directed disto-retrolaterally, supporting the embolus on the ventral and the dorsal side, respectively (Figs 16 A–F). In *Nostera*, the cymbium is convex on both sides and there is no posterior extension of the tegulum.

Description. Medium size spiders (5.0 – 8.0 mm), with smooth tegument. Prosoma longer than wide (L/W: 1.42 – 1.71), finely reticulated, sides rebordered and slightly undulated; fovea short. Prosoma widest at level of coxae II-III narrowed to about 0.41 – 0.52 x maximum width in males and 0.55 – 0.64 x maximum width in females (cephalic width measured on posterior tangent of PME). Cervical grooves

FIG. 4. *Nostera trifurcata* sp. nov. male holotype (QM-S15740): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, male palp, dorsal view; **E**, same, retrolateral view; **F**, same, ventral view. Scale bars: 1.0 mm.

clearly indicated. Profile highest between PME and fovea.

Colour: prosoma pale to reddish brown; chelicerae, legs, mouthparts and sternum pale to orange brown; opisthosoma dorsum medium to dark brown with fairly complex pale pattern of dots and chevrons, sides with oblique stripes; venter uniform pale or with darker longitudinal lines.

Eyes in two strongly procurved rows: PLE at level of AME. All eyes pale. Clypeus straight, height 1.4 – 2.7 times diameter of ALE. Chilum single, approximately twice as wide as height, with few setae. Chelicerae paturon twice as long as width, conical with weak lateral condyles and many evenly dispersed setae; fangs short. Labium is about 1.5 x longer than width, distally narrowed. Endites roughly triangular, converging, with basolateral extension accommodating palpal trochanters. Sternum shield-shaped, widest in the middle; anterior margin straight, lateral margins slightly sinuous.

Legs: fairly robust. Formula 1423. Spination reduced on legs I and II, well developed on III and IV. Most spines fairly short and slender.

Female palp with prolateral spines; palpal claw with some small teeth at base; without distal patch of chemosensitive setae.

Opisthosoma oval; tracheal spiracle fairly small, somewhat advanced and provided with small rectangular scutum. Both sexes with six spinnerets. ALS large, conical, biarticulate. PLS and PMS provided with 1 and 4 cylindrical gland spigots, respectively. Colulus represented by hairy field.

Male palp (Figs 16A-F): Cymbium with concave retrolateral side and retrolateral flange; a series of five or six distal spines but without distal claw; tegulum with large posterior extension reaching centre of tibia or further towards the base of the segment; subtegulum hidden by tegulum, conductor (C), and sclerotized median apophysis (MA), directed disto-retrolaterally, supporting the embolus on the ventral and the dorsal side, respectively; tibia with a bunch of setae on a slight ventro-lateral protrusion; RTA a parallel-sided, truncated prong.

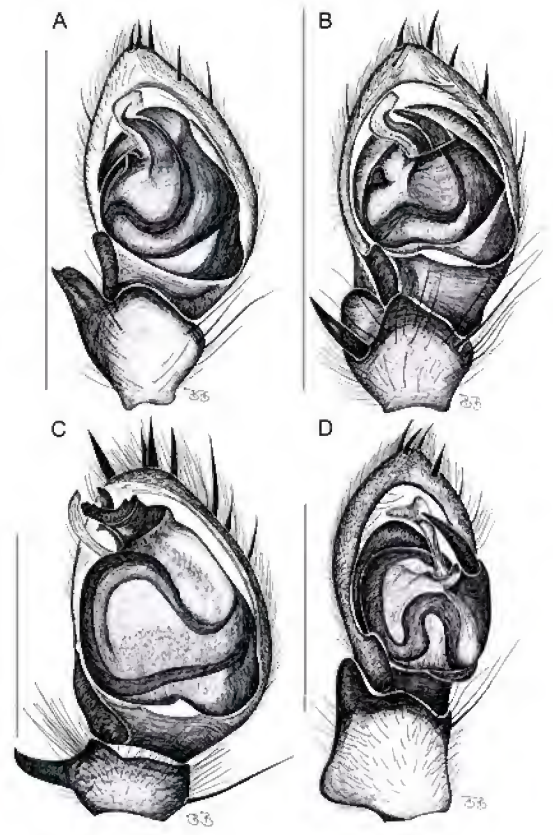

FIG. 5. Male palps for the genus *Nostera*, ventral view. **A**, *N. lynx*; **B**, *N. spinata*; **C**, *N. trifurcata*; **D**, *N. geoffgarretti*. Scale bars: 1.0 mm.

Epigyne (Fig. 7E, F), much wider than long with short rounded or triangular median septum (MS); with a posterior, membranous, rectangular epigynal window (W); copulatory openings (CO), just beside median septum; copulatory ducts (CD), thick convoluted ending in egg-shaped spermathecaes; fertilisation duct (FD), at posterior end of spermatheca.

KEY TO SPECIES OF THE GENUS *NOSTERELLA*

1. Males 2
– Females (unknown for *N. christineae*, *N. fitzgibboni*) 7

2. All eyes reduced to tiny dots (Figs 8A) . . . . . *N. cavicola*

– Eyes normal (Fig. 6A) 3

3. Palpal conductor (C) slender; MA tip without hood (Fig. 16C, E) 4

– Palpal conductor (C) broad; MA tip with hood (Fig. 16D, F) 5

4. Tip of MA straight (Figs 13F, 16E) . . . . . *N. fitzgibboni*

– Tip of MA curved (Figs 10F, 16C) . . . . . *N. christineae*

5. RTA strongly recurved from ventral view (Figs 14F, 16F) . . . . . *N. pollardi* (NSW)

– RTA slightly recurved from ventral view (Figs 6F, 11F, 16A, D) 6

6. Seminal duct clearly s-curved (Figs 11 F, 16D) . . . . . *N. diabolica* (NSW)

– Seminal duct with straight retrolateral section (Figs 6F, 16A) . . . . . *N. nadgee*

7. All eyes reduced to tiny dots (Fig. 9A) . . . . . *N. cavicola*

– Eyes normal (Fig. 7A, D) 8

8. Epigastric fold without LI; MS widely triangular (Fig. 12 E) . . *N. diabolica* (NSW)

– Epigastric fold with LI (Figs 7 E, 15 E) . . . 9

9. Epigastric fold with deep LI, MS rounded (Fig. 15 E) . . . . . *N. pollardi* (NSW),

– Epigastric fold with shallow LI, MS triangular (Fig. 7 E) . . . . . *N. nadgee*

Nosterella nadgee (Jocqué, 1995)
(Figs 6A–F, 7A–F, 16A, 17B)

Nostera nadgee Jocqué, 1995: 154, figs 8b-d.

Material examined. New South Wales: 1 female (AM KS59651), Booti Booti NP, south of Foster - opposite Great Lakes Yacht Club, 32°16′S, 152°31′E, L. Wilkie, 13 Nov 1996, pitfall. Queensland: 1 male (QM S12193), Archookoora SF, via Nanago, 26°43′S, 151°46′E, rainforest 110 m, G. Monteith, 1975 -1976, pitfall; 1 male, 1 female (QM S4282), Braemar State Forest via Kogan, 27°13′S, 150°50′E, open woodland, G. Monteith, 18 Oct 1979, berlesate; 2 males, 2 females (QM S96337), Brisbane, 32 Kingfisher Street, Albany Creek, 27°21′S, 152°58′E, in mud wasp nest, J. Stanisic, Nov 2015; 1 male (QM S12197), Brookfield, 27°30′S, 152°55′E rainforest 110 m, G. Monteith, 1975 -1976, pitfall; 1 male (QM S65594), Buhot Creek, Burbank, 27°35′S, 153°10′E, 50 m, riparian forest, R. Raven, 6 Nov 2003, day hand coll.; 1 male (QM S96347), Cold Ck., 28°28′S, 152°40′E, 122m, G. Monteith, 9 Nov – 31 Dec 1974, pitfall; 1 female (QM S96348), same as previous; 1 male (QM S12100), same as previous; 1 female (QM S57245), Cooran Tableland (barracks), 26°17′S, 152°50′E wet sclerophyll 400 m, G. Thompson, 12 Apr 1995, berlesate; 1 male (QM S96354), Crystal Cascades, carpark, 16°58′S, 145°40′E, R. Raven, P. Lawless, M. Shaw, 23 Jul – 26 Nov 1992, pitfall; 1 male (QM S19993), same as previous; 1 male (QM S12103), Dingo Ck via Traveston, 26°20′S, 151°52′E, rainforest 30 m, G. Monteith, 1974 -1975, pitfall; 1 male (QM S12104), same as previous; 1 male (QM S96353), Enoggera Reserve, 27°27′S, 152°54′E, 150 m, G. Monteith, J.Holt, 21 Dec 1999 – 27 Jan 2000, pitfall; 1 male (QM S12111), Gallangowan, 26°26′S, 152°17′E rainforest 487 m, G. Monteith, 1974 -1975, pitfall; 1 male (QM S4329), Gold Ck Reservoir, Brookfield, 27°30′S, 152°55′E, closed forest, V. Davies, R. Raven, 16 Dec 1980, pitfall; 1 female (QM S4306), same as previous, 18 Mar – 8 Apr 1981, pitfall; 1 male (QM S96338, image), Lake Broadwater via Dalby, 27°21′S, 151°05′E, V. Davies, 16 May – 23 Nov 1985, pitfall; 1 female (QM S96343, image), same as previous except M. Bennie, 3 Jan – 25 Feb 1986; 1 m, 3 females (QM S47401), same as previous; 11 males (QM S47397), same data as previous; 2 males, (QM S47609), same as previous except 24 Nov 1985 – 3 Jan 1986; 1 male, (QM S47610), same as previous; 4 males, 2 females (QM S47400), same as previous; 1 male, (QM S47404), same as previous; 1 female, (QM S47399), same as previous except 25 Feb – 22 Apr 1986; 3 males, 2 females (QM S35287), same as previous except 23 Apr – 11 Jun 1986; 1 male, 1 female (QM S47409), same as previous except 22 Apr – 12 Jun 1986; 1 male, 1female, (QM S47611), same as previous; 3 females, (QM S47408), same as previous except 26 Jan -19 Feb 1985; 2 females, (QM S47405), same as previous except 19 Feb -26 Mar 1985; 1 female, (QM S47406), same as previous except 26 Mar -17 May 1985; 1 male, (QM S47402), same as previous except 17 May -24 Nov 1985; 2 females (QM S47395), same as previous except 18 Feb-25 Mar 1985; 1 male, (QM S47407), same as previous except 17 May -24 Nov 1985; 2 males, (QM S47612), same as previous; 5 males (QM S12109), Marys Ck SF, via Gympie, 26°15′S, 152°35′E rainforest 183 m, G. Monteith, 1974 -1975, pitfall; 2 males (QM S12110), same as previous; 10 males (QM S96339), Mt Roberts 2 km NNW, 21°21′S, 148°29′E, softwood scrub 360 m, D. Cook & G. Monteith, 23 Oct – 18 Dec 2000, pitfall; 1 male (QM S47403) Stockhaven 3 km SE, 25°48′S, 151°59′E, 450 m, rainforest, G. Monteith & C. Gough, 10 Oct – 19 Dec 1998, intercept trap; 12 males (QM S47515), same as previous; 1 male (QM S12191), Yarraman 3 km E, 26°50′S, 152°03′E, rainforest 518 m, G. Monteith, 1974 -1975, pitfall; 1 male (QM S4259), same as previous.

Distribution. This species is known from New South Wales and Queensland (Fig. 17B).

FIG. 6. *Nosterella nadgee* (Jocqué, 1995) male (QM-S96338): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, male palp, dorsal view; **E**, same, retrolateral view; **F**, same, ventral view. Scale bars: 1.0 mm.

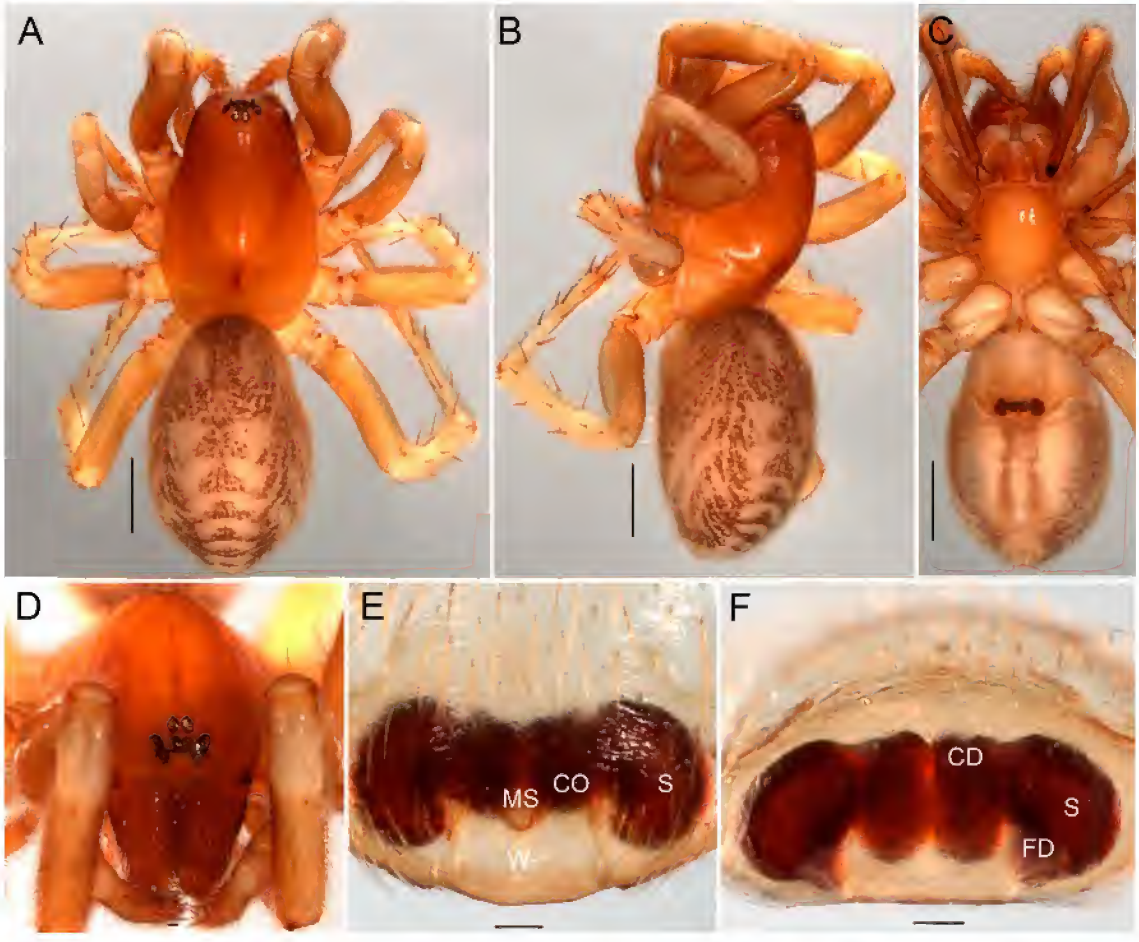

FIG. 7. *Nosterella nadgee* (Jocqué, 1995) female (QM-S96343): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, prosoma, anterior view; **E**, epigyne, ventral view; **F**, epigyne, dorsal view. CD copulatory duct; CO copulatory opening; FD fertilization duct; MS, median septum; S spermatheca; W window of epigynum. Scale bars: habitus 1.0 mm, epigyne 0.1 mm.

Nosterella cavicola sp. nov.
(Figs 8 A–F, 9 A–F, 16B, 17C)

Material examined. MALE HOLOTYPE (QM S96355), from Queensland, Mt Surprise, Bayliss Cave, Stn 6, 18°25'S, 144°28'E, F.G. Howarth, S. Robinson, 13 Jun 1986, hand coll.; FEMALE ALLOTYPE (QM S25706), same as previous.

Remarks. Female in burrow with elevated turret and small opening, male on mud at burrow opening.

Etymology. The specific name is an adjective referring to the habitat of the species.

Diagnosis. *Nosterella cavicola* can be separated from all other species by the pale opisthosoma without any pattern except a darker lanceolate dorsal stripe and the strongly reduced eyes (Figs 8A, 9A, D).

Description. Male (Holotype, QM S96355). Total length 7.91. Prosoma 4.21 long, 2.59 wide, pl/pw 1.62; sternum 1.61 long, 1.45 wide, sl/sw 1.11; opisthosoma 3.7 long, 2.36 wide. Eyes strongly reduced, tiny, both eye rows strongly procurved, ALE largest; ALE 0.08; AME 0.08; PLE 0.06; PME 0.06; ALE-ALE 0.36; ALE-AME 0.11;

AME-AME 0.07; ALE-PLE 0.09; PLE-PME 0.25; PME-PME 0.06. Clypeus 0.48 high. Prosoma dark brown, long oval, slightly reticulated, posteriorly straight, sides rebordered and slightly undulated, fovea short. Chelicerae dark brown; paturon twice as long as wide with weak lateral condyles. Endites, labium and sternum brown, tips of endites and labium pale; opisthosoma pale with darker lanceolate stripe; venter pale anterior to epigastric fold darker. Legs medium brown, coxae, trochantera and femora darker.

Male palp (Figs 8 D – F, 16B): cymbium dorsally covered with black setae and 10 thick spines in distal third; C slender straight, distally deeply excavated, MA narrow, straight, tip with flat hood; tibia with 2 strong, long macrosetae, RTA straight, distally incised.

Female allotype (QM S25706). Total length 8.00. Prosoma 4.04 long, 2.36 wide, pl/pw 1.71; sternum 1.50 long, 1.33 wide, sl/sw 1.13; opisthosoma 3.96 long, 2.54 wide. Colour as in male, except no lanceolate stripe dorsally. Eyes strongly reduced even more than in male, only front row visible, strongly procurved; ALE 0.07; AME 0.07; ALE-ALE 0.36; ALE-AME 0.13; AME-AME 0.04. Clypeus 0.50 high. Epigyne (Figs 9 E, F): Epigastric fold sinuous, with strong lateral incision, MS rounded.

Distribution. This nearly blind species is known only from Bayliss Cave in north-east Queensland (Fig. 17C).

Nosterella christineae sp. nov.
(Figs 10 A–F, 16C, 17C)

Material examined. MALE HOLOTYPE (QM S55170), from Queensland, Rochedale State Forest, 27°37'S, 153°09'E, V. Davies, R. Raven, 25 – 28 May 1980.

Etymology: The specific name is a patronym in honour of Christine Robertson, the Senior Media Officer of the Queensland Museum, who loves spiders and always finds ways to create public attention for our newly discovered spider species.

Diagnosis. *Nosterella christineae* can be separated from the other *Nosterella* species by the presence of two prolateral macrosetae on the palpal tibia, and the tapered and curved MA (Figs 10 D – F).

Description. Male (Holotype, QM S55170). Total length 5.66. Prosoma 3.25 long, 2.22 wide, pl/pw 1.46; sternum 1.54 long, 1.28 wide, sl/sw 1.20; opisthosoma 2.41 long, 1.63 wide. Eyes; both eye rows strongly procurved, AME largest; ALE 0.15; AME 0.16; PLE 0.15; PME 0.13; ALE-ALE 0.24; ALE-AME 0.04; AME-AME 0.03; ALE-PLE 0.02; PLE-PME 0.13; PME-PME 0.05. Clypeus 0.24 high. Prosoma entirely yellow orange, oval, reticulated, posteriorly straight, sides rebordered and slightly undulating, fovea short. Chelicerae light brown; paturon twice as long as wide with weak lateral condyles. Endites, labium and sternum yellow orange, tips of endites and labium white; opisthosoma pale brown with lighter lanceolate stripe followed by one pair of pale spots and four transverse pale bands; venter pale. Legs yellow, femora slightly darker.

Male palp (Figs 10 D – F, 16C): cymbium kidney-shaped, longer than wide, covered with black setae and 7 thick spines in distal third; C slender, straight, distally slightly excavated, MA slender, straight, tip without hood; sperm duct slightly s-shaped, distally hidden behind C and MA; palpal tibia with two prolateral macrosetae, RTA broad straight (dorsal view), ventrally excavated.

Female unknown.

Distribution. Known only from the Brisbane area in southern Queensland (Fig. 17C).

Nosterella diabolica sp. nov.
(Figs 11 A–F, 12 A–F, 16D, 17C)

Material examined. MALE HOLOTYPE (AM KS99595), from New South Wales, 4 km NE of Mt Wog Wog (Mountain), 17 km SE Bombala, 37° 04' 30" S, 149° 28' 00" E, 37°04'S, 149°28'E, C.R. Margules, Apr 1994, pitfall; FEMALE ALLOTYPE (AM KS59656), Wyrrabalong NP, 33°16'48"S, 151°32'45"E, L. Wilkie, 15 Apr 1998, pitfall; 3 males same as previous; 1male (AM KS59668), Booti Booti NP, south of Foster - opposite Great Lakes Yacht Club, 32° 16' 16" S, 152° 31' 43" E, L. Wilkie, 15 May 1998, pitfall; 2 males (AM KS59664), Myall Lakes NP, 3.8km south of Mungo Brush campsite, 32° 34' S, 152° 17' E, L. Wilkie, 24 May 1998, pitfall; 2 males (AM KS59673), same as previous; 1 male (AM KS99660), same as holotype but May 1991; 1 female (AM KS99606), same as holotype; 1 male (AM KS99599), same as holotype but May 1998.

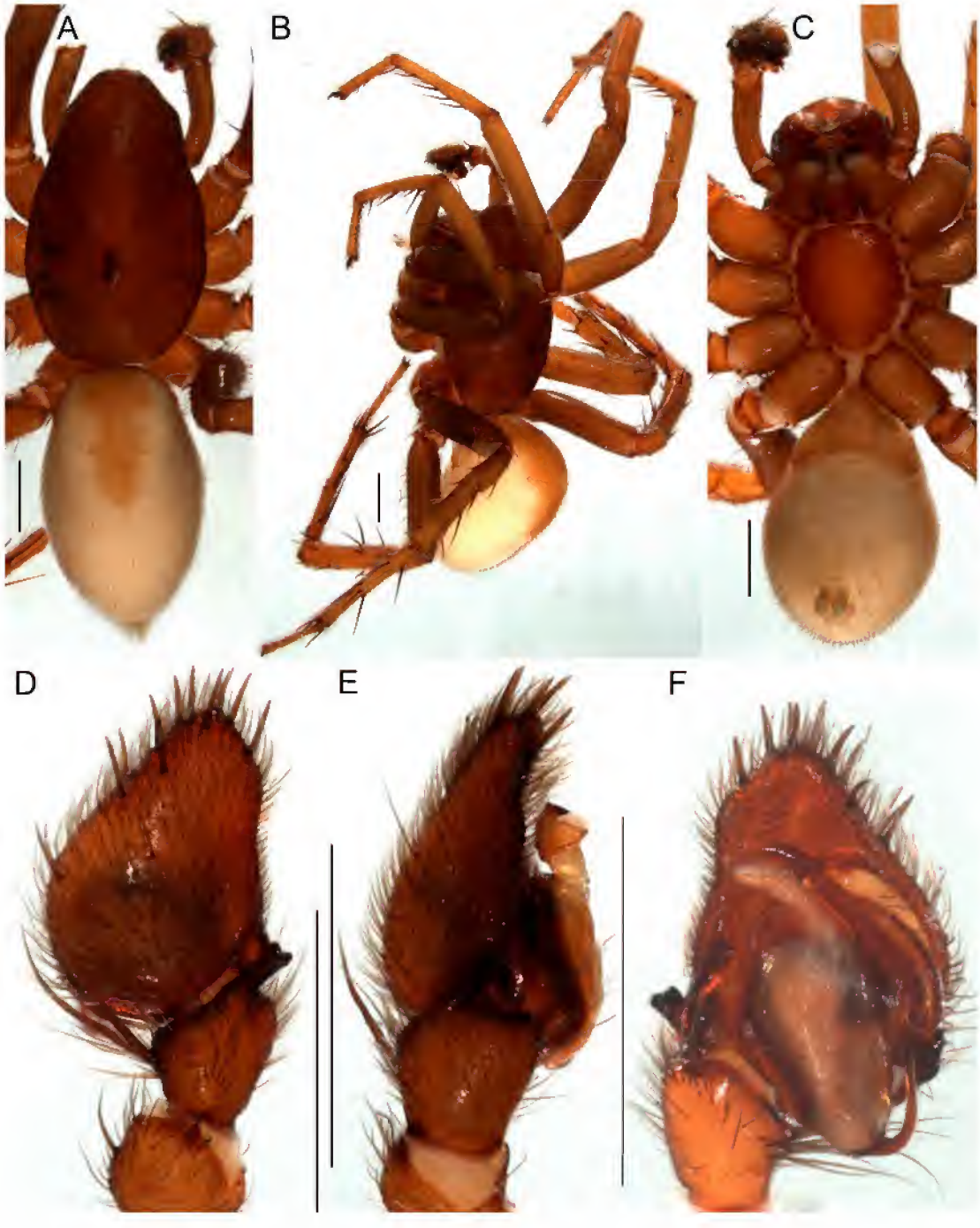

FIG. 8. *Nosterella cavicola* sp. nov. male holotype (QM-S96355): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, male palp, dorsal view; **E**, same, retrolateral view; **F**, same, ventral view. Scale bars: 1.0 mm.

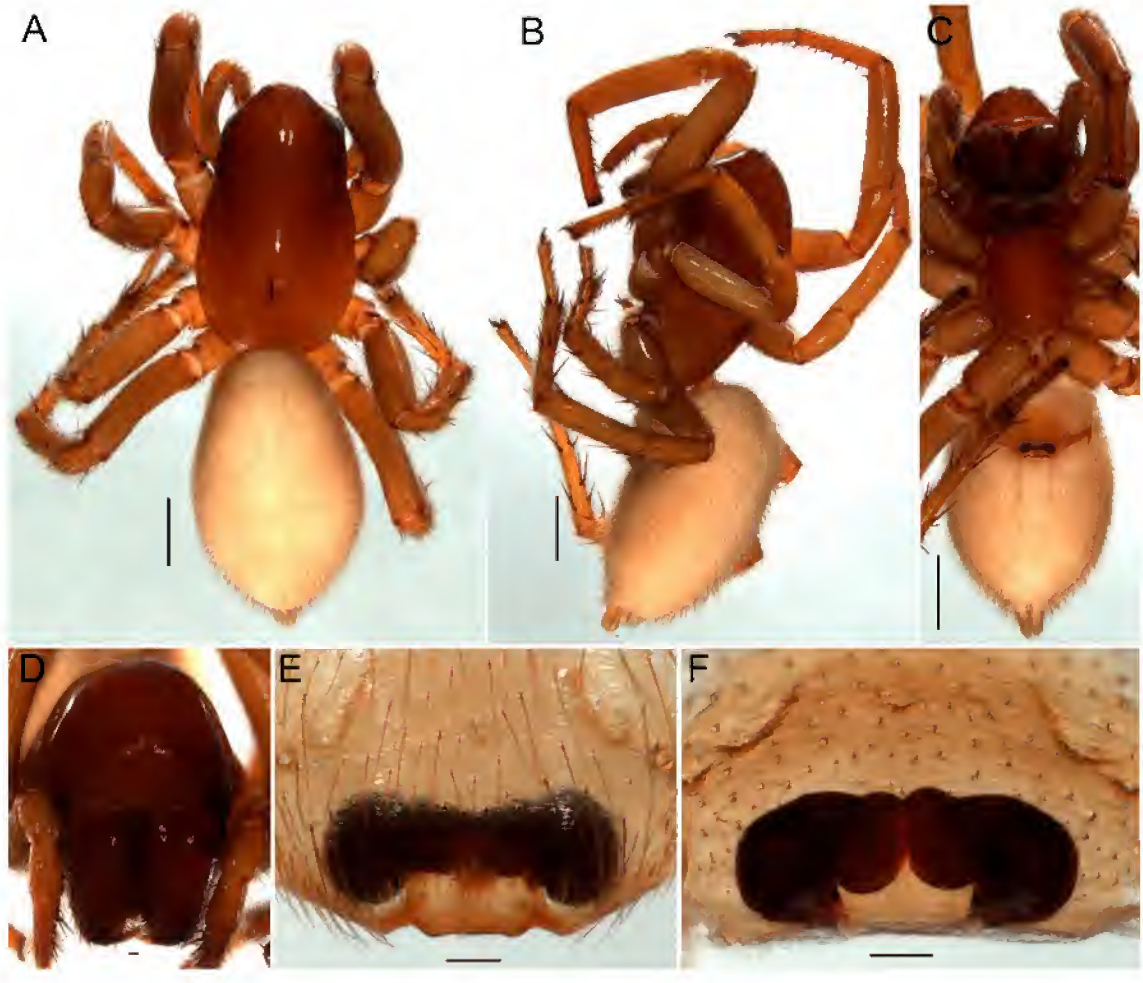

FIG. 9. *Nosterella cavicola* sp. nov. female allotype (QM-S25706): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, prosoma, anterior view; **E**, epigyne, ventral view; **F**, epigyne, dorsal view. Scale bars: habitus 1.0 mm, epigyne 0.1 mm.

Etymology: The specific name is an adjective referring to the dark colour of the species.

Diagnosis. Males of *Nosterella diabolica* can be separated from males of other *Nosterella* species, by the dark brown femora contrasting with the orange coxae and trochanters; the seminal duct in the tegulum is strongly S-curved (Fig. 11 F).

Description. Male (Holotype, AM-KS99595). Total length 5.71. Prosoma 3.06 long, 2.07 wide, pl/pw 1.48; sternum 1.32 long, 1.05 wide, sl/sw 1.25; opisthosoma 2.65 long, 1.74 wide. Eyes, both eye rows strongly procurved, ALE and PLE largest; ALE 0.14; AME 0.12; PLE 0.14; PME 0.11; ALE-ALE 0.21; ALE-AME 0.05; AME-AME 0.02; ALE-PLE 0.02; PLE-PME 0.12; PME-PME 0.05. Clypeus 0.21 high. Prosoma dark brown, oval, reticulated, posteriorly straight, sides rebordered and slightly undulating, fovea short. Chelicerae dark brown; paturon twice as long as wide with weak lateral condyles. Endites, labium and sternum medium brown, tips of endites and labium pale; opisthosoma dark brown with paler lanceolate medium stripe and two pairs of pale spots dorsally, followed by five transverse pale bands; venter dark brown with one big

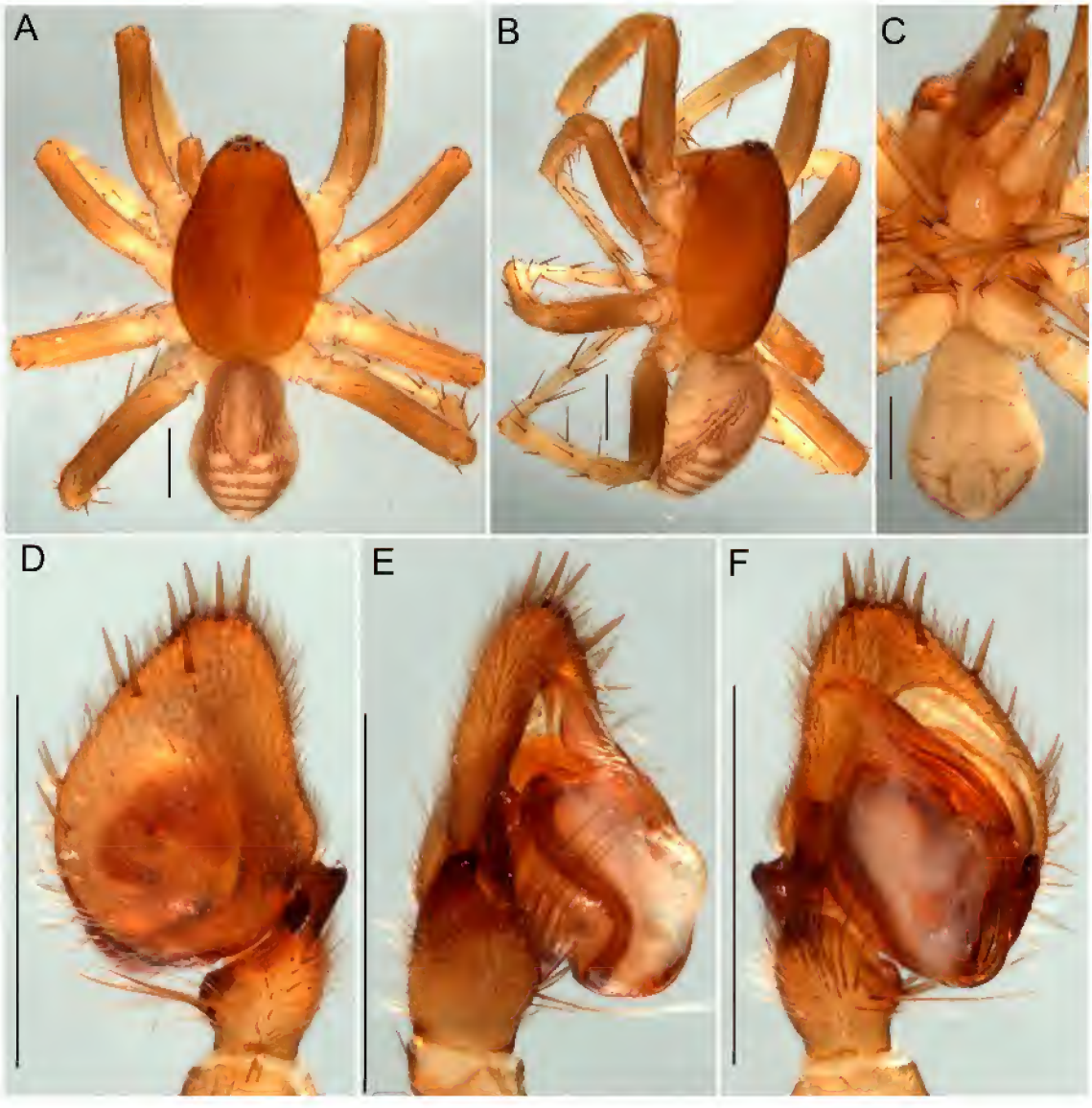

FIG. 10. *Nosterella christineae* sp. nov. male holotype (QM-S55170): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, male palp, dorsal view; **E**, same, retrolateral view; **F**, same, ventral view. Scale bars: 1.0 mm.

pair of pale spots. Legs orange brown, coxae, trochantera orange, femora dark brown.

Male palp (Figs 11 D – F, 16D): Cymbium covered with black setae and 6 thick spines in distal third; C curved, with median ridge, MA base widened, tip with well-developed hood; sperm duct strongly s-shaped; palpal tibia with a single short, thick macroseta, RTA slightly recurved at the tip.

Female allotype (AM KS59656). Total length 6.39. Prosoma 3.31 long, 2.19 wide, pl/pw 1.51; sternum 1.41 long, 1.33 wide, sl/sw 1.06;

FIG. 11. *Nosterella diabolica* sp. nov. male holotype (AM-KS099595): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, male palp, dorsal view; **E**, same, retrolateral view; **F**, same, ventral view. Scale bars: 1.0 mm.

FIG. 12. *Nosterella diabolica* sp. nov. female allotype (AM-KS59656): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, prosoma, anterior view; **E**, epigyne, ventral view; **F**, epigyne, dorsal view. Scale bars: habitus 1.0 mm, epigyne 0.1 mm.

opisthosoma 3.08 long, 2.06 wide. Colour as in male. Eyes, both eye rows strongly procurved, AME, ALE and PLE largest; ALE 0.15; AME 0.15; PLE 0.15; PME 0.13; ALE-ALE 0.24; ALE-AME 0.04; AME-AME 0.03; ALE-PLE 0.01; PLE-PME 0.16; PME-PME 0.05. Clypeus 0.27 high. Epigyne (Figs 12E, F): Epigastric fold without lateral incision, MS widely triangular.

Distribution. This species is known only from New South Wales (Fig. 17C).

Nosterella fitzgibboni sp. nov.
(Figs 13 A–F, 16E, 17C)

Material examined. MALE HOLOTYPE (QM S96336), from Queensland, Carnarvon Station, Brigalow (*Acacia harpophylla*), 24°49'S, 147°44'E, 741 m, Bush Blitz, B. Baehr, 9-16 Oct 2014, pitfall.

Etymology. The specific name is a patronym in honour of Paralympian Daniel Fitzgibbon who has not let his injuries get in the way of pursuing his passion of sailing and competing in the Olympics winning a gold medal in London (2012) and Brasil (2016).

Diagnosis. Males of *Nosterella fitzgibboni* can be separated from males of other *Nosterella* species, by the two macrosetae on the prolateral side of the tibia, and the straight MA (Figs 13 F, 16E).

Description. Male (Holotype, QM S96336). Total length 6.02. Prosoma 3.23 long, 2.13 wide, pl/pw 1.52; sternum 1.54 long, 1.30 wide, sl/sw 1.30; opisthosoma 2.79 long, 1.97 wide. Eyes, both

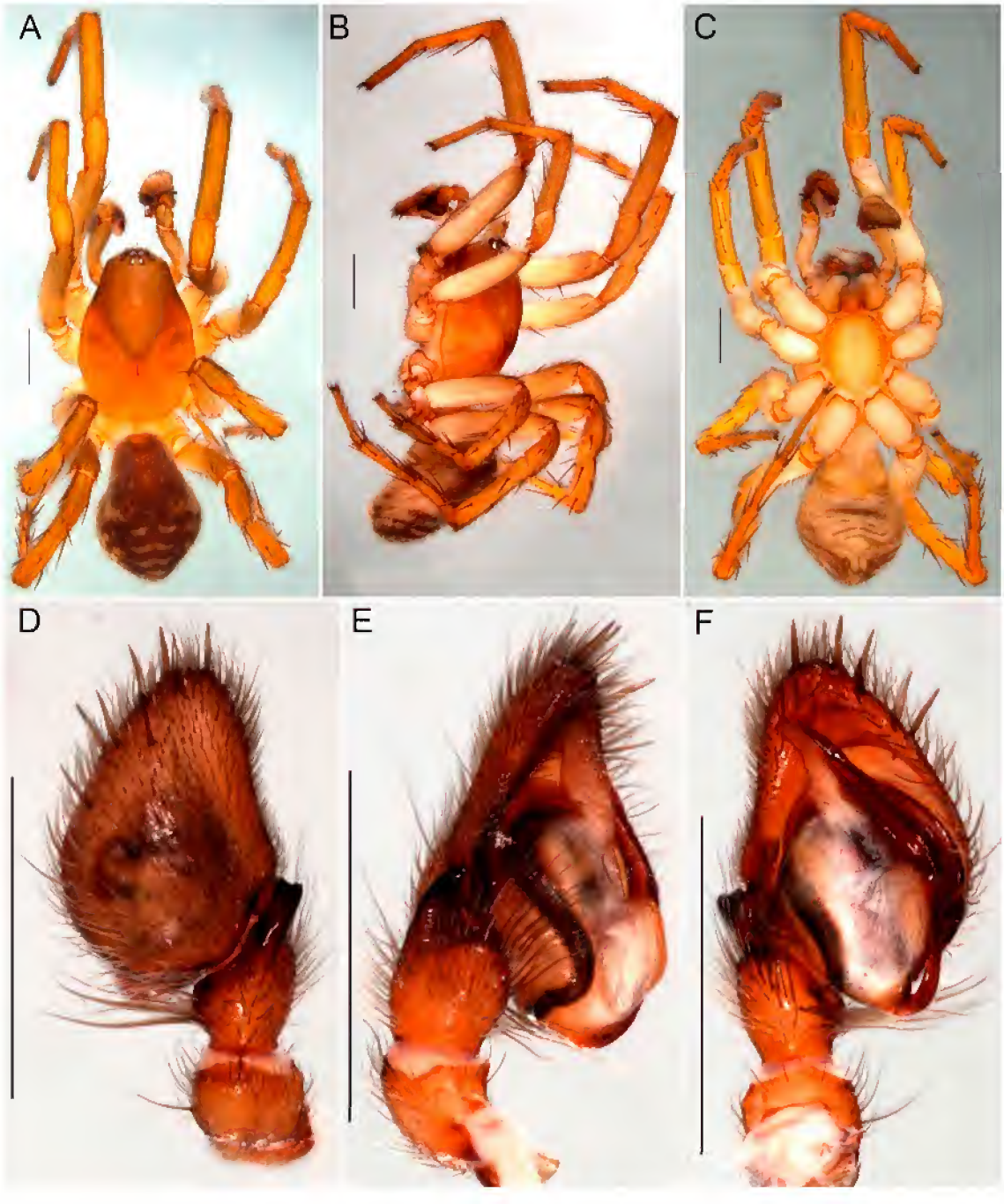

FIG. 13. *Nosterella fitzgibboni* sp. nov. male holotype (QM-S96336): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, male palp, dorsal view; **E**, same, retrolateral view; **F**, same, ventral view. Scale bars: 1.0 mm.

FIG. 14. *Nosterella pollardi* sp. nov. male holotype (QM-S96344): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, male palp, dorsal view; **E**, same, retrolateral view; **F**, same, ventral view. Scale bars: 1.0 mm.

FIG. 15. *Nosterella pollardi* sp. nov. female allotype (QM-S47398): **A**, habitus, dorsal view; **B**, habitus, lateral view; **C**, habitus, ventral view; **D**, prosoma, anterior view; **E**, epigyne, ventral view; **F**, epigyne, dorsal view. LI lateral incision at epigynal fold. Scale bars: habitus 1.0 mm, epigyne 0.1 mm.

eye rows strongly procurved, AME largest; ALE 0.15; AME 0.17; PLE 0.15; PME 0.13; ALE-ALE 0.25; ALE-AME 0.05; AME-AME 0.02; ALE-PLE 0.03; PLE-PME 0.12; PME-PME 0.06. Clypeus 0.21 high.

Prosoma yellow orange with a darker brown cephalic area, oval, reticulated, posteriorly straight, sides rebordered and slightly undulating, fovea short. Chelicerae medium brown; paturon twice as long as wide with weak lateral condyles. Endites, labium and sternum yellow orange, tips of endites and labium white; opisthosoma dark brown with two pairs of tiny pale dots dorsally followed by four thin transverse pale bands; venter pale. Legs yellow, femora pale brown.

Male palp (Figs 13D–F, 16E): Cymbium covered with black setae and 7 thick spines in distal third; C slender, straight, distally slightly excavated, MA slender, straight, tip without hood; sperm duct slightly s-shaped, distally hidden behind C and MA; palpal tibia with two prolateral macrosetae, RTA straight (dorsal view), tip slightly indented.

Female unknown.

Distribution. Known only from Carnarvon Station, Queensland (Fig. 17C).

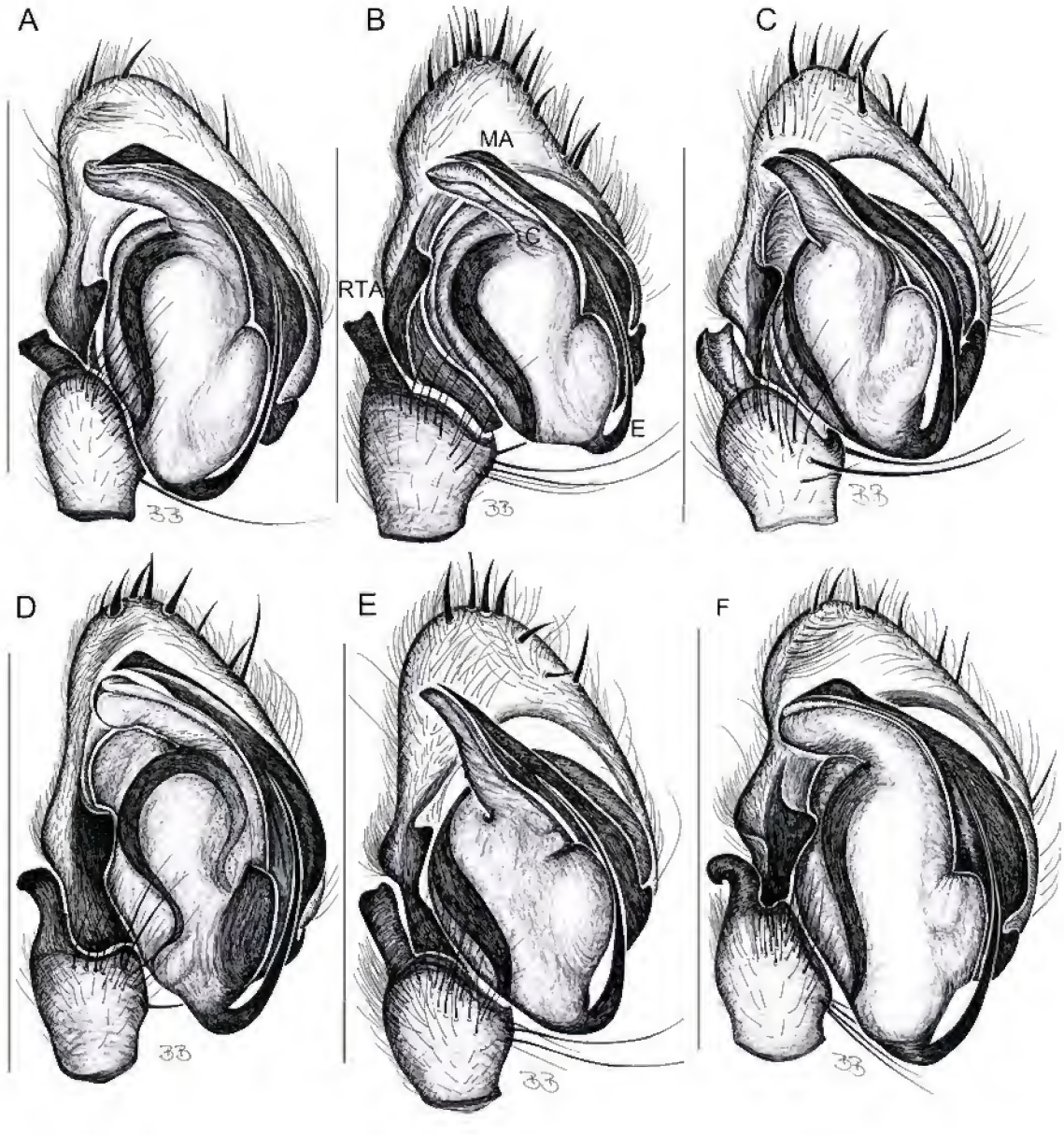

FIG. 16. Male palps for the genus *Nosterella*, ventral view. A, *N. nadgee*; **B**, *N. cavicola*; **C**, *N. christineae*; **D**, *N.diabolica*; **E**, *N. fitzgibboni*; **F**, *N. pollardi*. C conductor; E embolus; MA Median apophysis; RTA retrolateral tibial apophysis. Scale bars: 1.0 mm.

Nosterella pollardi sp. nov.
(Figs 14 A–F, 15 A–F, 16F, 17C)

Material examined. MALE HOLOTYPE (QM S96344), from New South Wales, Lord Howe Island, 31°33'S, 159°05'E, 40 m, G. Monteith, 22 Nov 1979, sieved litter; FEMALE ALLOTYPE (QM S47398), same as previous; 1 male (QM S47394), same as previous except south end, 16 Nov1979.

Etymology. The specific name is a patronym in honour of Peter Pollard, Associate Professor at the Australian Rivers Institute, Griffith University; Peter is a Microbial Ecologist with a PhD in Chemical Engineering and Microbiology from the University of Queensland and his marine and freshwater research has changed the way we see the relationships between microbes and their role in coastal zones, rivers, lakes, and wetlands. The ant-eating spider *Nosterella pollardi*, which lives only on Lord Howe Island surrounded by water, is named to honour Peter Pollard's achievements in marine and freshwater research.

Diagnosis. Males of *Nosterella pollardi* can be separated from the other *Nosterella* species, by the MA tip with well developed hood, by one poorly developed prolateral macroseta and the tibial apophysis strongly curved retrolaterally (Figs 14F, 16F).

Description. Male (Holotype, QM S96344). Total length 5.77. Prosoma 3.10 long, 2.19 wide, pl/pw 1.42; sternum 1.39 long, 1.11 wide, sl/sw 1.25; opisthosoma 1.67 long, 1.91 wide. Eyes, both eye rows strongly procurved, PLE largest; ALE 0.15; AME 0.14; PLE 0.16; PME 0.13; ALE-ALE 0.24; ALE-AME 0.03; AME-AME 0.03; ALE-PLE 0.03; PLE-PME 0.14; PME-PME 0.03. Clypeus 0.24 high. Prosoma dark brown, oval, reticulated, posteriorly straight, sides rebordered and slightly undulating, fovea short. Chelicerae medium brown; paturon twice as long as wide with weak lateral condyles. Endites, labium and sternum medium brown, tips of endites and labium pale; opisthosoma dark brown with pale lanceolate medium stripe and two pairs of pale spots dorsally, followed by five transverse pale bands; venter pale with 2 fainted brown stripes medially. Legs medium brown.

Male palp (Figs 14D–F, 16F): Cymbium covered with black setae and 6 thick spines in distal third; C broad, curved, with slightly excavate tip, MA base widened, tip with well-developed hood; sperm duct slightly s-shaped;

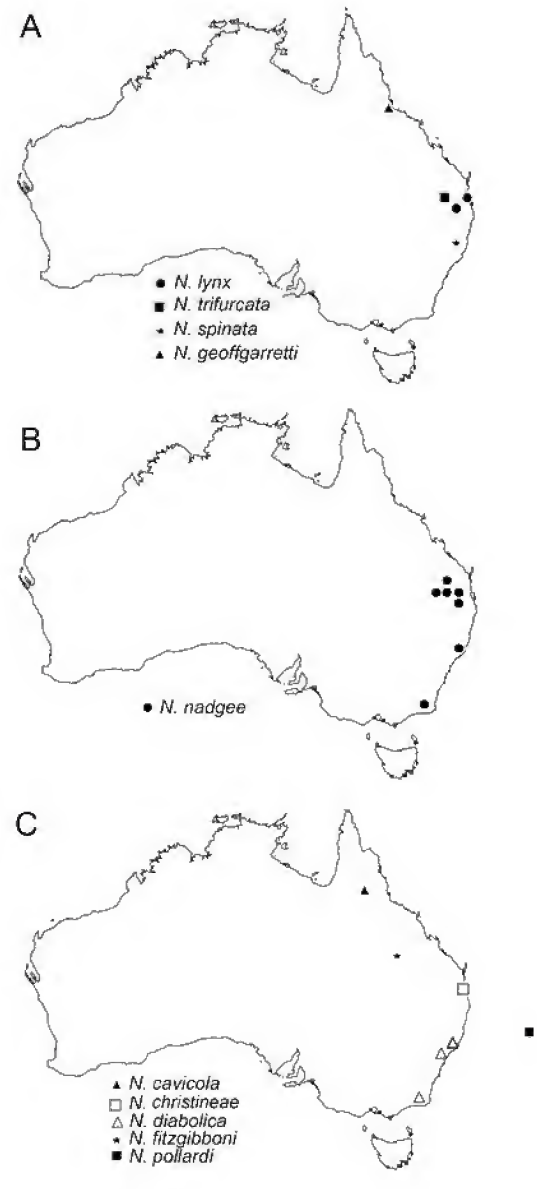

FIG. 17. Distribution Maps: **A**, species of the genus *Nostera*; **B**, *Nosterella nadgee*; **C**, species of the new genus *Nosterella*.

palpal tibia with a single poorly developed prolateral macroseta, RTA strongly curved retrolaterally.

Female allotype (QM S47398). Total length 6.83. Prosoma 3.31 long, 2.09 wide, pl/pw 1.58; sternum 1.52 long, 1.27 wide, sl/sw 1.20; opisthosoma 3.52 long, 2.28 wide. Colour as in male. Eyes, both eye rows strongly procurved, AME, ALE and PLE largest; ALE 0.14; AME 0.14; PLE 0.14; PME 0.12; ALE-ALE 0.25; ALE-AME 0.05; AME-AME 0.05; ALE-PLE 0.02; PLE-PME 0.14; PME-PME 0.05. Clypeus 0.36 high. Epigyne (Figs 15 E, F): Epigastric fold with deep lateral incision, MS rounded.

Distribution. This species is known only from Lord Howe Island (Fig. 17C).

DISCUSSION

The new genus *Nosterella* is quite homogeneous. There are only slight differences between the male and female genitalia of the different species. This might indicate that these species are the result of clear allopatric speciation. Jocqué (2009) discussed this issue in the genera *Systenoplacis* and *Capheris* and concluded that the increased complexity is more common in sympatric speciation.

The reduction of the eyes in *N. cavicola* supports this hypothesis because the genitalia are still very similar to the general pattern found in the genus. The species clearly belongs to *Nosterella* and the eye reduction character does certainly not warrant the creation of a separate genus. In those cases where eye reduction was used as an argument to create a separate genus, it was always in combination with a number of other characters, either somatic or genital. Examples of such troglophile genera are *Plutonodomus* Cooke, 1964 (Cooke, 1964) in the Prodidomidae, and *Ciba* Bloom *et al.*, 2014 (Bloom *et al.*, 2014), in the Ctenidae.

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Field observations provide an insight into the ecology of the Rusty Monitor (*Varanus semiremex*) in South-eastern Queensland, Australia

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ABSTRACT

A southern population of the Rusty Monitor (*Varanus semiremex*) is known to occur at Wild Cattle Creek, Tannum Sands, Queensland. Thorough field observations conducted on foot revealed that individuals are frequently observed active between late September and April. Five distinct adults were identified over a 300 metre length of tidal mangrove habitat. Two confirmed females had a set home range and were recorded active within the same areas during a 29-month period. Both females became gravid and laid eggs between October and December. Hollows in mangrove trees were used as refuge sites and may be occupied over time by several individuals. Crabs were the only prey items observed, in contrast to literature reports of a more varied diet. The monitors were not active swimmers, preferring to forage between tides, but using the water in-transit where necessary. Daily activity commenced early in the summer months but was delayed during autumn and spring. Activity was observed at temperatures as low as 25.5°C. ❐ *Varanus semiremex, crab-feeding, activity, home range, thermal regulation, mangrove species.*

Varanus semiremex (Peters 1869) is a species of varanid distributed along the coast and neighbouring river systems of Queensland. This species is endemic to Queensland and known to occur from the Gladstone region (South-eastern Queensland) to Cape York (Wilson & Swan 2013; Cogger 2014). It is commonly referred to as the Rusty Monitor due to its rusty colouration under the throat and chest but is quite variable in colour-pattern over its distribution. Cogger (2014) listed *V. semiremex* as inhabiting mangroves and the borders of freshwater streams adjacent to the coast. Jackson (2005) who collected the southern form and bred captive individuals at Australia Zoo suggested that the southern populations are restricted to coastal mangroves, with their habitat being dominated by the Spotted Mangrove *Rhizophora stylosa* and the Grey Mangrove *Avicennia marina*. Within these habitats the monitors are known to feed on crustaceans, fish, lizards, insects and small mammals (Dunson 1974; Swanson 1976; Ehmann, 1992; Vincent & Wilson 1999; James *et al.* 1992; Jackson 2005; Pianka *et al.* 2004; Cogger 2014).

While much is known about diet, habitat preferences and husbandry of *V. semiremex*, little is known about its natural feeding behaviour, thermal preferences and daily and seasonal activity patterns. Pianka *et al.* (2004) noted that 'this wary and uncommon diurnal monitor is seldom seen', a reference that points to the difficulties in studying this cryptic species. Recent field observations (2013) from the Tannum Sands region revealed that a healthy population of *Varanus semiremex* exists in this area.

Observations of specimens encountered at Tannum Sands site over a 29-month period provide new information on the biology of this species. The observations outlined here add to the known ecology for this species. Whilst this study began as an observational exercise purely for interest, the data accumulated adds significantly to the scant knowledge available for this species and has flow-on conservation applications. No monitors were handled during the study and the utmost care was taken to avoid disturbing the monitors or their habitat.

Study area

Wild Cattle Creek is a tidal salt water creek separating Wild Cattle Island from the mainland. Its mouth is situated south of Tannum Sands (23°57′S, 151°22′E) in Queensland and meanders through to the Colosseum (a bay) some kilometres to the south. Each side of the creek is dominated by a mangrove habitat of which 300 metres on the western side was selected as a study site (Fig. 1). For conservation reasons and the welfare of the monitors the site is not specifically mapped. Numerous species of mangrove trees occur at this locality including the Red Mangrove (*Rhizophora stylosa*) and larger Grey Mangrove (*Avicennia marina*). Two other species of mangroves the Yellow Mangrove (*Ceriops tagal* var. *australis*) and River Mangrove (*Aegiceras corniculatum*) are also common but restricted to the shoreline. The habitat is consistent with that described in Jackson (2005) as favourable for *V. semiremex* in SEQ.

METHODS

To gain an insight into the behaviour of the Rusty Monitor the designated area was visited 183 times, commencing 16 September 2013 and concluding on the 15 February 2016. Attempts were made to visit the area numerous times each month at close to regular intervals. During these visits, between 1-3 hours typically, the area was surveyed several times and observations of the Rusty Monitor were captured using a high resolution digital camera (Nikon D800) and telephoto lens (Nikon 300 mm with 1.4 tele-converter attached; 420 mm equivalent). To avoid disturbing natural behaviour, specimens were approached cautiously and quietly. Much emphasis has been placed on gaining

FIG. 1. Wild Cattle Creek

acceptance of individuals. No attempts were made to disturb individuals to gain a better image. Brief visits outside the study period were also conducted during September-December 2016.

Identification of individuals

To assist in the identification of individuals, each animal was photographed from multiple angles, with emphasis on obtaining profile shots. An accurate profile was achieved by cropping images down to head shots. Arrangement of head scales, eye ring (complete circle or not), size of tubercles and nostril shape were characteristics that could be used to differentiate individuals. A 10 x 15 cm image of each observation was printed for a direct comparison. These images were used to assess population size and the daily and seasonal movements of individuals.

Observations. To minimise disturbance specimens were approached cautiously and quietly. Specimens were followed while they foraged and images were taken showing both foraging behaviour and the range of prey items consumed. The 420 mm lens equivalent enabled images to be taken from a reasonable distance (typically 6 metres). Each time a specimen was photographed the time was recorded with the image file and the location was later plotted using a Garmin GPS (sites A-Z). Due to the inaccuracy of the GPS used (generally +/- 5 metres) the site was properly mapped out later by using a tape measure and the trilateration method (mapping an area by the use of triangles).

Sex. The sex of two females was determined by closely examining a series of images (taken over a few weeks) that display a pre-partum and post-partum state. No males were confirmed, although specimen 4 (Fig.2.) had head scaring and a more pronounced head structure which is consistent with an adult male.

TABLE 1. Commencement of activity temperatures and times throughout Autumn, Spring and Summer.

Temperature	Time	Date
28°C	11:47 am	18 April 2014
26°C	9:36 am	30 September 2013
30°C	9:01 am	29 October 2014
28°C	8:22 am	3 December 2014

Thermal Information. Tree hollow, basking site and active foraging temperatures were measured at Site B, a mangrove tree frequently used. Three 'J' type thermocouples were setup to record these temperatures by use of a Fluke, 10 Channel, Digital Thermometer. The long thermocouple leads allowed temperatures to be recorded 12 metres away and out of direct sight. Daily temperatures were also recorded from the Bureau of Meteorology (20 kilometres distant). To establish the minimum foraging temperature of animals, a temperature data logger was placed in the shade of a mangrove at the study site to measure more specific temperatures.

RESULTS AND DISCUSSION

Study Population. Between site A and site H (approximately 300 metres) eight individuals were positively identified by comparing digital images of 126 observations (Fig. 2). Five adults were identified along with two sub-adults and a juvenile. Specimens were placed into these categories by an estimation of age, overall size and strength of lip barring (strong in juveniles). Photographs of uncertain individuals were recorded during behaviour and daily activity assessments.

Daily Activity/Thermal Preferences. Rusty Monitor individuals were diurnally active and basked in the morning sunlight from an elevated position (Fig. 3). Commencement of activity varied between seasons and was delayed when the weather had cooled in autumn; refer Table 1.

An example of thermal activity is given in Fig 4. Direct foraging into the mudflats only occurred during the warmer months (21 observations). During the cooler months, specimens restricted their foraging to the shoreline (3 observations). Avoiding the wet mud and shaded areas of the mangrove habitat during the cooler months is behaviour that would assist in maintaining a suitable body temperature. Most of the shoreline habitat in the study area is sandy and is in direct sunlight from midday onwards. A

FIG. 2 Left and right head views of five adults identified in this study. Top-bottom, specimens 1–5.

FIG. 3. *Varanus semiremex* basking.

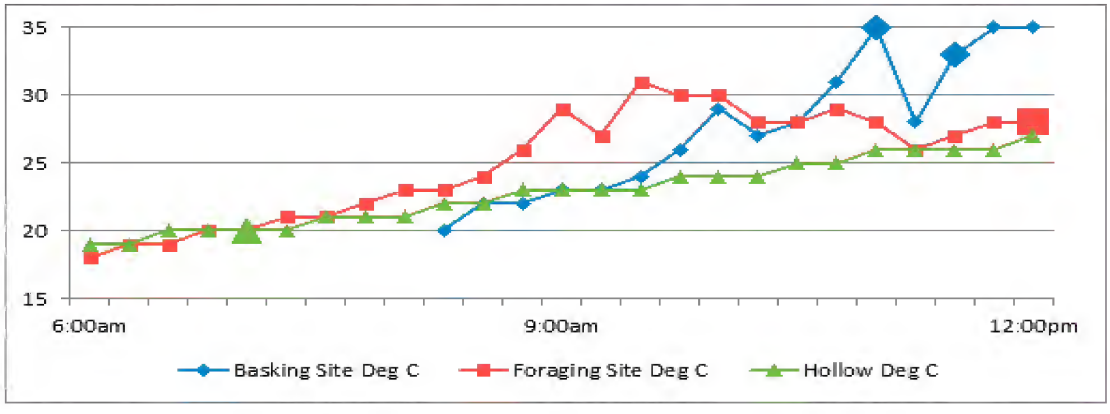


FIG. 4. Microhabitat temperatures measured at site B on 18th April 2014. Larger data points highlight the animal's emergence from hollow (triangle), basking next to thermocouple (diamonds) and commencement of foraging (square), respectively.

detailed record of daily temperatures measured throughout the study are listed in Table 3.

Seasonal Activity. Rusty Monitors were observed active from mid-September until late April (47 observations). During late autumn and early winter, activity was reduced to the occasional head basking (the animal poked its head out of its shelter site but did not emerge completely). No activity was recorded from mid-June to early September when temperatures were cooler (34 observations, Fig. 5). Activity resumed in mid-September

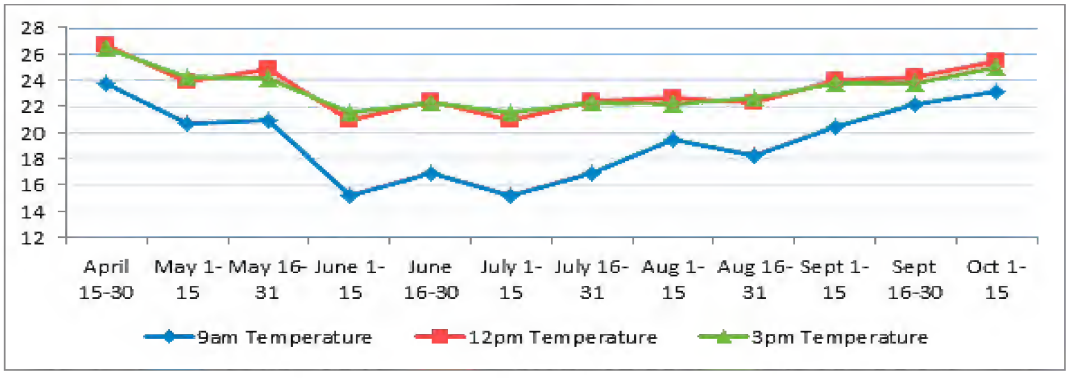


FIG. 5. Fortnightly average temperatures at Gladstone, 2014 from Bureau of Meteorology.

when the daily temperature range had risen to a minimum of 15ºC and maximum of 27ºC. The lowest measured air temperature (at site) when an individual was active was 25.5ºC, recorded at 10:50am during late September 2014. Figure 5 displays average fortnightly temperatures at 9am, 12pm and 3pm, showing the decline in available thermal energy at 9am and 12pm from late May until late August.

Refuge Sites. Hollows in large mangrove trees were used as semi-permanent refuge sites. Other hollows in stumps and living mangrove trees, many below high tide level, were used as temporary refuge sites. Site H, a hollow log that was frequently used by Specimen 1, is below water level during king tides. Site H was avoided as a sheltering site during this period, but frequently used at other times (18 observations). Table 2 briefly describes the refuge sites throughout the study area. Refuge site usage is also displayed in table 2.

Semi-aquatic Behaviour. (Fig 6) Monitors were seen to enter the water rarely (7% of observations) and only during the warmer months (9 observations, December-March; Figures 6A, B). While there are few observations of this activity due to varying tidal heights and times (only a high tide that engulfs the mangrove flat and overlaps foraging time), the animals are very capable swimmers. For example, I observed an individual climbing down a mangrove tree and swimming to another tree to pursue a crab. Close examination of images from two observations showed that as the monitors swam, all limbs were held against the body (in a crocodile-like manner) whilst the head and mouth were kept above water. The tail was moved in lateral undulations providing forward propulsion. Various individuals were also seen perched on isolated logs during high tide levels (3 observations). This study confirms *V. semiremex* favours semi-aquatic environments, although there is no indication of underwater foraging behaviour such as Merten's Water Monitor, *V. mertensi* (Swanson 1976).

Feeding Behaviour. (Figs 7A-F) A broad range of prey items are recorded for the Rusty Monitor (Dunson 1974; Swanson 1976; Ehmann 1992; Vincent & Wilson 1999; James *et al.* 1992; Jackson 2005; Pianka *et al.* 2004; Cogger 2014). However, only crabs were observed as prey items during this study even though a number of other potential prey species (mudskippers, mud lobsters, fish) also inhabit the site. Crabs were actively foraged for and pursued in the open or dug from burrows (14 observations). A range of crabs species were eaten at different tide times. At high tide *Metopograpsus frontalis* often perches on the trunk of mangrove trees and debris above the water level and; it is highly likely this is the crab species consumed in at least 2 observations. During outgoing tides, the Purple and Cream Shore Crab (*Pseudohelice subquadrata*) was extracted from the sandy substrate surrounding the buttressed base and

TABLE 2. Site usage; number of times used by each individual during the study period.

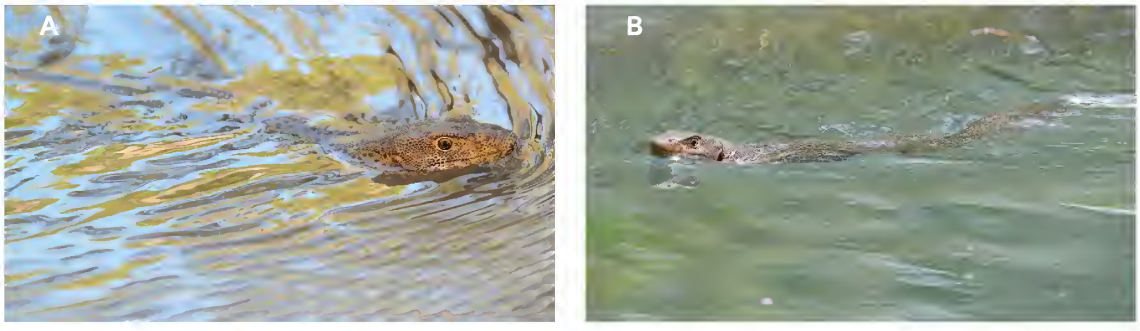
Site	Rustee Spec. 1	Rosette Spec. 5	Russel Spec. 2
A Grey Mangrove	1	-	-
A1 Yellow Mangrove	1	-	-
S Red Mangrove	-	1	-
B Red Mangrove/ hollow	6	15	-
R Red Mangrove	1	2	-
U Red Mangrove/ hollow	3	5	-
T Grey Mangrove/ hollow	2	2	1
Z Grey Mangrove/ hollow	1	-	-
K Stump/ hollow	1	10	2
L Grey Mangrove/ hollow	3	3	1
C Grey Mangrove/ hollow	-	4	2
V Grey Mangrove	-	1	-
P Red Mangrove	-	2	1
J Stump/ hollow	-	5	-
Y Log/ hollow	-	2	-
X Stump	1	-	-
Q Red Mangrove	1	-	3
N Red Mangrove	-	-	-
M Grey Mangrove/ hollow	-	-	-
D Log/ hollow	3	-	1
W Red Mangrove	1	-	-
G Grey Mangrove/ hollow	5	-	2
E Red Mangrove	-	-	-
F Felled Mangrove	-	-	2
O Red Mangrove/ hollow	-	-	1
I Red Mangrove/ hollow	1	-	-
H Log/ hollow	18	-	-

root system of the Yellow Mangrove (*Ceriops tagal* var. *australis*, 1 observation, Figs 7A and 7B). Other crab species inhabiting the mud flats were pulled from their burrows during foraging (2 observations, Figs 7C, 7D). In one observation a crab evaded capture by moving between entrances of a 'V' shaped tunnel (defence behaviour). When a crab was pursued around the trunk of a tree and the monitor moved into a lateral position, the monitor wrapped its tail around the tree trunk to assist balance (1 observation). Crabs were swallowed whole and were often rotated until their limbs were on each side of the goanna's jaw (3 observations, crab limbs protruding from monitor's mouth). One swallowed crab was regurgitated and crushed against the log numerous times before being re-swallowed (Figs 7E, 7F).

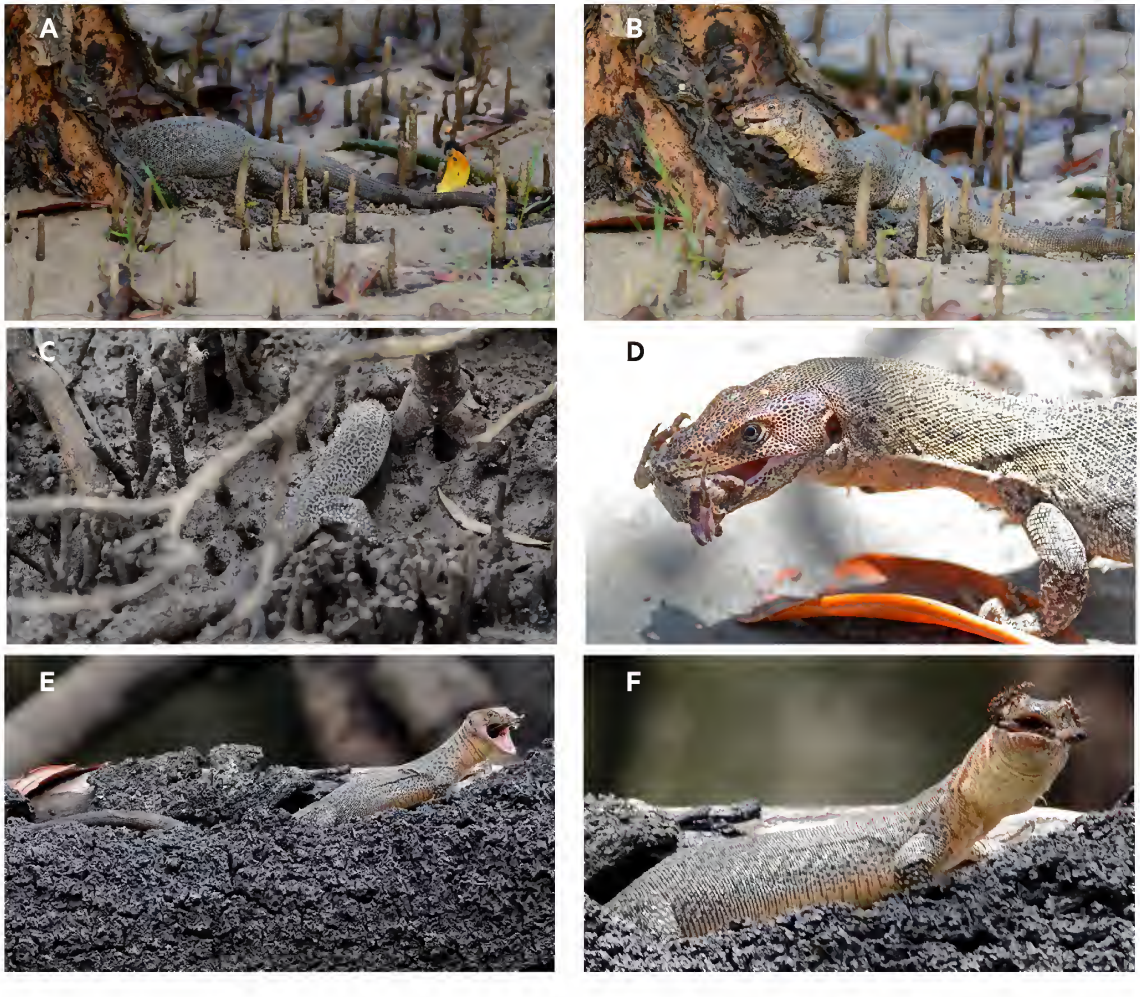
A small hollow stump next to site K (1 m high) was used as a vantage point (2 observations). Two individuals used this site on separate occasions and were observed attentively watching the ground below. When a suitable prey item was spotted, the monitor slowly moved forward before dropping to the ground below and actively pursuing its victim.

Salt Excretion. It is well documented that the Rusty Monitor responds to the high salt intake from feeding on saltwater crabs by expelling excess salt through the nostrils from specialised nasal salt excretion glands (Dunson 1974; Heatwole 1976; Ehmann 1992; Vincent & Wilson 1999). Adult specimens encountered during this study were all observed sneezing and often to the degree of releasing a visible spray. While all adults conformed to this behaviour, there is no mention of regular sneezing in captive individuals that were held at Australia Zoo during their breeding program (Jackson 2005). It is fair to surmise that the fresh water and prey provided to captive individuals (mainly fish, prawns and crickets with some cockroaches and the occasional pink mouse) contain much lower salt levels than the crabs eaten (often with a mouth full of moist sand) from a tidal mangrove flat; hence, the need to purposely sneeze for salt excretion would be reduced.

Sexing of Individuals and Longevity. *Varanus semiremex* and other pygmy goannas are notoriously difficult to sex by the usual method of determining males by gently exposing the hemipenis (Jackson 2005; K. Aland pers. com.). However, this level of disturbance was not



FIGS. 6A, B. Swimming behaviour of *Varanus semiremex;* head is clearly held out of the water and limbs tucked against the body.



FIGS. 7A-F. *Varanus semiremex* feeding behaviour, **A-B**, observed along sandy shoreline; **C-D**, within the mangrove flats; **E-F**, on a fallen mangrove tree.

FIGS. 8A-G. Pre-partum and post-partum changes within female *Varanus semiremex*. **A-C**, display Rustee (Spec. 1) in a pre-partum and post-partum state; **D-G**, display Rosette (Spec. 5) in a similar pre-partum and post-partum state.

appropriate for this study. Instead, two females were able to be identified by a series of images displaying the changes that occur during the pre-partum and post-partum state. While the sex of two other adults was undetermined, one individual with snout scarring (consistent with intra-specific aggression), a more pronounced head structure and colourful throat (Fig. 2, specimen 4) is likely to be a male. Intra-specific aggression between males is known in the varanid family and often results in a scarred or injured individual (King & Green 1999). Longevity for the two females was calculated as a minimum of 3¾ years (specimen 5) and

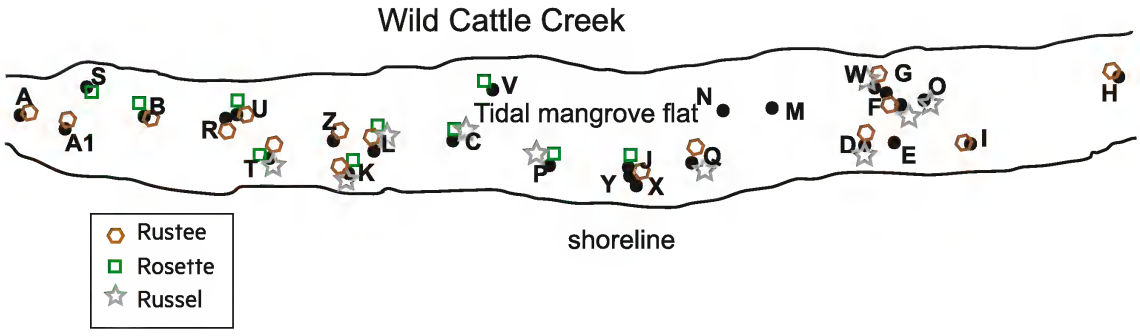


FIG. 9. A scaled representation of sites A-Z within the study site. Distance between site A and H is approximately 293 metres. The grey lines are an estimation of shoreline and creek bank. Site A is deemed a northern extremity of the study site and site H a southern extremity.

4¼ years (specimen 1). This was established from head images taken throughout the study period and brief visits to the study site during September–December 2016. Both specimens were large adults and at least 1-year-old when first encountered. Jackson, 2005 measured the growth rate of captive hatchlings and concluded that specimens reached maturity after 15 months. The last observations of Specimen 5 and Specimen 1 occurred on the 28th and 31st December 2016 respectively. Due to the lack of long term observations of the other 3 adults, it was not possible to determine their age.

Egg Deposition. Two individuals underwent changes in morphology consistent with developing and laying eggs. Protruding hips, a drawn in tail base, distension in the posterior portion of the abdomen and lumps protruding from the belly are all typical signs of a gravid female. (Jackson 2005; K. Aland pers. com.). On the 26th and 28th of September 2015, Rustee (specimen 1) was the first specimen observed at site H in what appeared to be a pre-partum state (Fig. 8A-B). Two weeks later, 12th of October 2015, Rustee was again observed at site H but in an apparently depleted post-partum state (Fig. 8C).

Rosette (specimen 5) was photographed in an apparent pre-partum state on two occasions, first at site U on the 10th December 2015 and six days later at site J on 16th December 2015 (Fig. 8D-E). On the 24th of December 2015, Rosette was photographed again at site U in an obvious post-partum state (Figs. 8F, G). Figures 8C and 8F display both Rustee and Rosette in a very similar state. It is not known where either of these individuals laid their eggs; however, during the study there were no observations of any active individuals venturing to potential ground egg-laying sites. Jackson (2005) used nest boxes replicating a hollow log to successfully breed captive *Varanus semiremex*. As such, the egg deposition of wild *V. semiremex* probably occurs in mangrove tree hollows between late September and December.

Movements and home range. Monitors often moved between shelter sites and readily sought refuge in hollows that were previously occupied by other individuals (Fig. 9. Tables 2, 3). Foraging distance and time has been measured at 20 metres in 6 minutes.

The maximum linear distance travelled in a 24-hour period was ~182 metres and was recorded when Rustee ventured from site A (1st February 2015) to site Q (2nd February 2015); refer Fig. 9. Short term movements were recorded for both Rustee (specimen 1) and Rosette (specimen 5).

Rustee's movements over 13 days (28th January-10th February 2015; Table 3) included site W→ (4days) A→ (1 Day) X→ (4 days) G→ (4 days) L.

Rosette's movements over 9 days (27th November- 6th December 2014; Table 3) included

TABLE 3. Site selection, temperatures and movements of specimens 1, 2 and 5. Highlighted sites in grey indicate when individuals were observed at more than one site during an observation day.

d= distance travelled in metres from first location of previous observation day.
T= min/max temperatures in Deg. C BOM Gladstone, temperatures in bold were measured at an interval of 3 hours that overlap observation (BOM) and temperatures with (*) represent specific temperatures measured at site.

RUSTEE - specimen 1											
Date	**Site**	**d**	**T**	**Date**	**Site**	**d**	**T**	**Date**	**Site**	**d**	**T**
24/09/13	H	-	**24/26**	28/09/13	H	-	**25/28**	13/10/13	H	-	**25/27**
14/10/13	H	-	**29/29**	30/03/14	I	43	**27/29**	24/09/14	H	43	**23/23**
07/10/14	G	62	**24/26**	31/10/14	H	62	**26/27**	03/12/14	G	62	**22/28**
08/12/14	D	15	**28/31**	11/12/14	L	131	**30/32**	12/12/14	R	40	**26/27**
22/12/14	T→U	15	**26/29**	28/01/15	W	163	**27/29**	01/02/15	A	229	**29/33**
02/02/15	X→Q	166	**26/31**	06/02/15	G	71	**27/28**	10/02/15	L	137	**27/29**
28/02/15	B	62	**27/30**	02/03/15	G	198	**24/28**	05/03/15	L	137	**28/32**
06/03/15	B→A1	62	**29/31**	10/03/15	K→Z→B	57	**31/31**	15/03/15	B	57	**26/28**
16/03/15	B	-	**27/30**	13/09/15	H	260	16/26	14/09/15	H	-	15/26
17/09/15	H	-	15/30	18/09/15	H	-	17/28	24/09/15	H	-	12/24
26/09/15	H	-	12/26	28/09/15	H	-	**25/25**	12/10/15	H	-	18/27
05/12/15	H	-	20/31	06/12/15	H	-	21/31	21/12/15	H	-	23/30
30/12/15	D	69	20/30	03/01/16	D	-	24/29	16/01/16	B	192	23/31
18/01/16	U	25	22/30	01/02/16	H	235	27/33	10/02/16	T→U	227	23/31
15/02/16	G	165	-								
RUSSEL - specimen 2											
Date	Site	d	T	Date	Site	d	T	Date	Site	**d**	**T**
04/10/13	D		**21/25**	09/01/14	F→G	14	**24/24**	02/10/14	G→F	6	**23/26**
22/10/14	O	12	**25/26**	02/12/14	Q	64	**23/26**	03/12/14	Q	-	**28/29**
04/12/14	Q	-	**27/29**	12/12/14	C→P	64	**26/27**	16/12/14	K	30	**28/30**
06/02/15	C→L→ K→T	30	**27/28**								
ROSETTE - specimen 5											
Date	**Site**	**d**	**T**	**Date**	**Site**	**d**	**T**	**Date**	**Site**	**d**	**T**
12/04/14	B	-	**27/28**	17/04/14	B	-	**26/28**	10/09/14	L	62	**25/25**
11/09/14	L	-	**23/28**	13/09/14	B	62	**23/23**	14/09/14	B	-	**22/24**
15/09/14	B	-	26*	18/09/14	B	-	**23/26**	24/09/14	K	57	**23/23**
28/09/14	K	-	16/26*	29/09/14	K	-	**23/24**	03/10/14	K	-	27/28*
07/10/14	K	-	**24/26**	08/10/14	K	-	**22/27**	11/10/14	K	-	**22/25**
29/10/14	P→J	54	**23/30**	27/11/14	B	110	**29/28**	29/11/14	K	57	**25/26**
03/12/14	B	57	**22/28**	05/12/14	L	62	**27/27**	06/12/14	K	10	**25/26**
17/12/14	R	35	27/28*	20/12/14	S	40	**29/30**	31/12/14	C→V	99	**25/30**
27/01/15	B	83	**29/30**	28/01/15	B	-	**27/29**	10/02/15	Y→J	131	**27/30**
24/02/15	B→T	131	**27/30**	02/03/15	B	-	**28/32**	06/03/15	Y	131	**29/31**
10/03/15	P→J	21	**28/31**	02/10/15	B	110	15/27	07/10/15	B	-	16/27
07/12/15	U	25	22/29	10/12/15	U	-	23/30	16/12/15	J	105	21/30
24/12/15	U	105	23/31	03/01/16	U	-	24/29	12/01/16	C	58	22/31
16/01/16	J	48	23/31	21/01/16	U	105	20/31	22/01/16	B	25	22/32
27/01/16	K	57	26/32	30/01/16	C	30	27/33	10/02/16	R→T	60	23/31
15/02/16	C	60	-								

venturing from site B→ (2days) K→ (4days) B→ (2days) L→ (1 day) K. While it was not possible to determine the movements of specimens between the days of recorded movements, the data do point out that specimens moved back and forth between sites.

Rustee a female that was commonly encountered during the study (43 observation days), had a preference for site H (refer Fig. 9) and the southern portion of the study site (28 observation days). During September-October over four consecutive years (2013, 2014, 2015 & 2016) Rustee was photographed perched on this site. Only on 15 observation days was Rustee observed venturing into areas usually inhabited by Rosette, another female that favoured site B and the northern half of the study site.

The recorded movements (46 observation days) of Rosette are more restricted than Rustee's with a strong preference for the northern section of the study area (north of site P, Fig. 9). Rosette was observed venturing to or further south than site P on only 6 observation days. Rosette was not recorded south of site Y. The habitat north of site A changes dramatically and is very unlikely to be suitable for foraging; hence, Rosette's movements do suggest a small home range of <0.6 hectares (estimated by using the shoreline and mangrove margins; Figs 1, 9). Due to site H being situated on the southern boundary of the study area, it was not possible to estimate Rustee's home range; however, the movements recorded in Table 3 support the probability of a home range well in excess of 1.0 hectare. A third adult Russel (Fig. 2, specimen 2) was observed ten times during the study (04/10/13-06/02/15) and was documented venturing between sites O and T (Table 3). Two other adults have been observed within the study site, but lack of observations has not enabled an assessment of long term movements. The long term movements of specimens 1, 2 and 5 are listed in Table 3.

Conspecific Interactions

Rustee and Rosette were both observed on 12 occasions and were usually spaced well apart (≥ 54 metres, 10 observations). Only once were both specimens observed in close proximity of each other (3 metres). On this occasion, Rustee tilted the head to watch Rosette below venture past but no intra-specific aggression was triggered between these females. Russel's activity has been observed on the same days as Rustee and/or Rosette, with the minimum distance between individuals exceeding 54 metres. Specimen 2 has not been observed since February 2015.

Predation. Although no predation on *V. semiremex* was observed during this study, numerous large predators, known to feed on reptiles, were observed within the immediate and adjacent areas. These include large birds of prey, two species of pythons and large species of monitors. However, indirect predation behaviour was observed during the study. On the 10th of March 2015 a large Coastal Carpet Python was observed investigating a tree hollow which had been occupied by a monitor 22 minutes earlier. A Rusty Monitor perched high on site K, a large dead tree stump, was observed retreating into its hollow as a Brahminy Kite flew overhead. A similar observation was noted when a specimen on site H clearly tilted its head and watched a bird of prey overhead. These final two observations show that Rusty Monitors are aware of potential aerial threats.

CONCLUSION

The Tannum Sands population of the Rusty Monitor (*Varanus semiremex*) appears to be totally restricted to the inter-tidal, mangrove habitat and shoreline of Wild Cattle Creek. No observation of activity venturing into neighbouring bushland was observed. Foraging activity was observed during the day when the air temperature was 25.5°C and above and occurred between September and May. Only crabs were recorded as prey items, highlighting the importance of a healthy mangrove habitat and water quality to support an abundant population of crabs for a sustainable rusty monitor population. There is no fresh water run off purposely channelled into the habitat and cane toads are rarely encountered. Specimens regularly sneeze, a response well documented

as a means of expelling salt (Dunson 1974). *Varanus semiremex* is a wary monitor with keen eyesight and is very observant to threats, both on the ground and aerial. This monitor is a capable swimmer but there has been no indication of true aquatic behaviour. To list *V. semiremex* as a semi-aquatic species is probably an overstatement of its true behaviour. The tail has a small degree of prehensile ability and is occasionally wrapped around a tree for support. The trunk and main branches of the Grey Mangrove and Red Mangrove trees were used frequently as basking sites, while the hollows of mature trees and logs offered temporary and semi-permanent refuge sites. No specimens were observed retreating into a burrow.

Apart from the breeding interactions with males, the two females studied closely lived solitary lives and had a small home range. Breeding occurred in late spring and early summer. Both females deposited eggs between late September and late December.

Male Rusty Monitors were not identified during the study and may be less detectable than the females. If consistent with other varanids, the males are likely to have a larger home range (Heatwole 1976). A larger home range of a male would reduce the probability of an encounter throughout the study site. The strong bias of records of the two females confirmed (77%) and the notion that an adult male was amongst the other 3 adults observed (23%) support this likelihood, particularly when both females bred during the study period. Continuity of the mangrove habitat along Wild Cattle Creek is essential to provide connectivity of the population. The home range of a male Rusty Monitor needs to be studied closely, probably by the use of telemetry.

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Andrew Amey and Patrick Couper encouraged me to pursue this study and their advice and comments on developing the manuscript is greatly appreciated. Andrew read, commented and edited progressive drafts. I am very grateful for Andrew's input and professionalism. Kieran Aland gave guidance on the arduous task of sexing Pygmy Goannas. Without Kieran's input and knowledge on this topic it would have been unlikely to draw many conclusions. Peter Davie identified the crab species inhabiting the study site. Mark Hutchinson and Peter Robertson both gave advice on sexual dimorphism in goannas. Alana Elkins my daughter assisted in surveying the site. My wife Inge is always supportive of my work and I thank her dearly for that. Thanks also to Melissa Bruton and Sarah Verschoore for helping a field naturalist reach the goal of a scientific publication. A special acknowledgement for Jeanette Covacevich (1945-2015), without her encouragement and guidance over the years this paper would have unlikely been written.

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Studies on Southwest Pacific Hexactinellida 1: *Atlantisella lorraineae*, a new glass sponge genus and species record for New Zealand

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ABSTRACT

A second species of *Atlantisella* Tabachnick, 2002 (Class Hexactinellida Schmidt, Order Lyssacinosida Zittel, Family Euplectellidae Gray) is described here from Tangaroa Seamount on the southern Kermadec Ridge, off the Bay of Plenty in northeastern New Zealand. The New Zealand species differs considerably from the North Central Atlantic type species, *A. incognita* Tabachnick, 2002, in lacking hexactine dermalia, by possessing calycocome-like oxyhexaster microscleres, and in the different form of the oxystauractins. *Atlantisella lorraineae* sp. nov. is named in memory of the co-author's mother, Mrs Lorraine Kelly, who passed away on 1 October 2016. ❐ *Hexactinellida, Lyssacinosida, Euplectellidae, Atlantisella, taxonomy, new species, Tangaroa Seamount, southern Kermadec Ridge, Chatham Rise, New Zealand EEZ*

Prior to this work, our knowledge of the glass sponge family Euplectellidae Gray in New Zealand waters was limited to three certain species, *Regadrella okinoseana* Ijima, 1896, *Walteria leuckarti* Ijima, 1896 and *W. flemmingi* Schulze, 1885, and eight undescribed species (Kelly *et al.* 2009). The discovery of only the second species of *Atlantisella* Tabachnick, 2002 in New Zealand waters, when the genus was previously known only from south of the Azores Archipelago in the Central Atlantic, is remarkable for the highly disjunct distribution.

The genus *Atlantisella* is presently classified as one of the five monospecific members of the subfamily Corbitellinae Gray (Order Lyssacinosida Zittel, Family Euplectellidae) since it is attached to hard substrate by a basal disc and lacks a stalk. The relationship of *Atlantisella* to other corbitellins is unclear; it bears pentactine dermalia, unusual for the family and shared with only three of the 26 genera, *Heterotella* Gray, 1867, *Placopegma* Schulze, 1895 and *Pseudoplectella* Tabachnick, 1990 and possesses a combination of microscleres not shared with any of those three genera. Moreover, the present arrangement of euplectellids into three subfamilies, Euplectellinae Gray, Corbitellinae and Bolosominae Tabachnick, the latter erected by Tabachnick (2002), is being increasingly questioned as an appropriate reflection of the phylogeny of the family. The arrangement was a slight modification of the older division of the family based primarily

upon the nature of substrate attachment, either rooted in sediments by anchoring spicules (Euplectellinae) or grappled onto hard substrate by a basal disc (Corbitellinae and now Bolosominae). This basic taxonomic division was previously questioned in a cladistic analysis of morphological characters by Mehl (1992) in her conclusion that *Euplectella* Owen, 1841, a rooted member hence classified in the subfamily Euplectellinae, has as closest sister *Regadrella* Schmidt, 1880, attached by basal disc and classified in the subfamily Corbitellinae. A more recent cladistic analysis of morphological characters (Henkel *et al.* 2015) corroborated that mode of substrate fixation in euplectellids is probably more plastic than generally appreciated and unsuitable for distinction at the subfamily level.

Recent molecular analyses (Dohrmann *et al.* 2012; Wörheide *et al.* 2012) lack strong support for the present taxonomic division of Euplectellidae based upon mode of attachment and it is clear that the classification of the family requires major revision. Unfortunately there are no molecular data available of *Atlantisella* to help clarify its relationship to other euplectellids. Although *Atlantisella* has remained monospecific since it was first proposed, Tabachnick (2002) alluded to another undescribed species off Hawai'i. This is probably one of the two undescribed *Atlantisella* species illustrated in the University of Hawai'i's HURL Animal Identification Guide (Anon 2016). Other undescribed *Atlantisella* species are illustrated from Central California (Burton & Lundsten 2008) and the Galápagos Islands (Van Soest *et al.* 2012).

Here we describe only the second known species of *Atlantisella*, from the southern Kermadec Ridge and the Graveyard Seamount complex on the northeast Chatham Rise, to the northeast and east of New Zealand, respectively. This new species of *Atlantisella* is named in memory of the co-author's mother, Mrs Lorraine Kelly, who passed away on 1 October 2016, after a long and difficult illness.

MATERIAL AND METHODS

Specimens were collected from Tangaroa Seamount on the southern Kermadec Arc (Fig. 1) by seamount sled onboard the National Institute of Water & Atmospheric Research (NIWA) research vessel RV *Tangaroa*; the collection station is cited as NIWA Stn TAN0XXX/XX. Purported images of living sponges identified as *Atlantisella lorraineae* sp. nov. were captured by DTIS (Deep Towed Imaging System) onboard RV *Tangaroa* from the southern Kermadec Arc and Chatham Rise (Fig. 2), courtesy of NIWA's Deepsea Mining of the Kermadec Arc and OS20/20 Chatham Rise biodiversity hotspots programmes. Specimens were either frozen at -10°C or preserved in 95% ethanol, and later transferred to 70% ethanol.

In the laboratory the holotype was first digitally photographed and 10 mm^2 samples were rinsed in water and digested in hot nitric acid (95°C) to obtain clean spicule suspensions. After cooling and diluting with water a 0.5 ml aliquot from one sample was filtered onto a 10 mm diameter polycarbonate micropore filter (0.2 µm ion-etched pores), dried and mounted on a scanning electron microscopy (SEM) stub with double-sided tape. The remaining suspensions were transferred to petri dishes and visually recognisable spicule types were picked by forceps or pipette under a dissecting microscope and transferred to individual dishes of water. These clean spicules were transferred individually by pipette or needle to clean 9 mm^2 cover glasses to which they quickly adhered by drying. The cover glasses were then attached to SEM stubs by epoxy.

Clean spicules remaining in the diluted nitric acid suspensions were processed for light microscopy (LM) by sequential filtration on three or four 25 mm diameter, 0.22 µm pore size nitrocellulose filters followed by air drying; spicule tufts were picked off of the last filters of each set by forceps when still wet and spread in water on a microscope slide and air-dried. After drying all of the filters and spicule spreads were mounted in Canada Balsam under cover glasses for LM. Because the holotype was too thin to reliably sample spicules from each

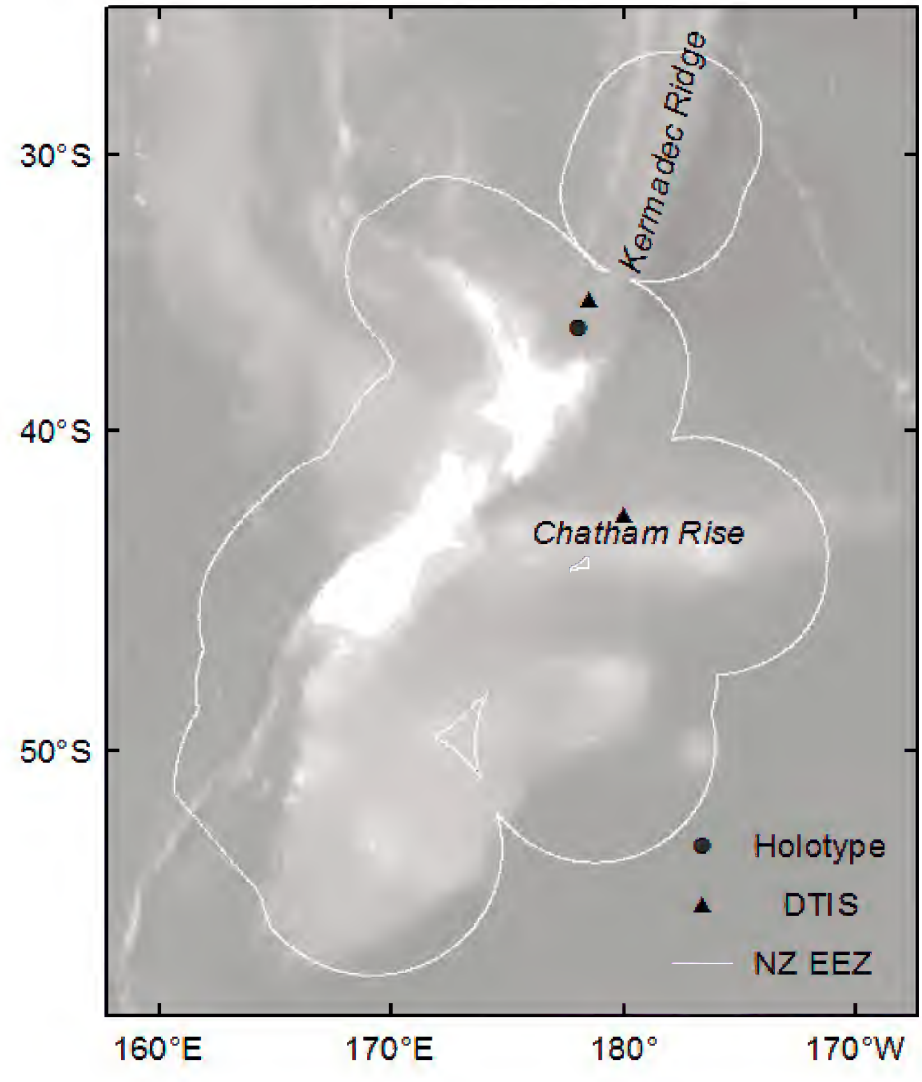

FIG. 1. Study area showing the collection locality of the holotype of *Atlantisella lorraineae* sp. nov. and the location of specimen images captured by DTIS on the southern Kermadec Ridge region (Rumble II West and Tangaroa Seamount) and Graveyard and Diabolical Seamounts on the Chatham Rise.

surface, a 10 mm² sample was whole-mounted in Canada Balsam to enable determination of the location of the various spicule types.

SEM preparations were sputter-coated with gold-palladium and imaged with a Hitachi S-3500 SEM at the Biology Department, University of Victoria. Spicules in the LM preparations were measured with a digitiser optically connected to either compound or dissecting LM by drawing tube (camera lucida) and Sigma-Scan® software. Dimensions are cited as mean (mean) and standard deviation (s.d.), range, and the number of measurements made (no.).

Primary type materials are accessioned within the NIWA Invertebrate Collection (NIC) at the National Institute of Water & Atmospheric

Research (NIWA), Greta Point, Wellington (prefix NIWA).

Abbreviations used in the text: DTIS, NIWA's Deep Towed Imaging System; HURL, Hawai'i Undersea Research Laboratory, University of Hawai'i; LM, light microscopy; NIC, NIWA Invertebrate Collection, Evans Bay, Wellington; NIWA, National Institute of Water & Atmospheric Research, Evans Bay, Wellington; No., number of measurements made; SEM, scanning electron microscopy; s.d., standard deviation.

SYSTEMATICS

Class HEXACTINELLIDA Schmidt, 1870

Order LYSSACINOSIDA Zittel, 1877

Family EUPLECTELLIDAE Gray, 1867

Atlantisella Tabachnick, 2002

Atlantisella Tabachnick, 2002: 1416–1418, fig. 18.

Type Species. *Atlantisella incognita* Tabachnick, 2002 (by original designation).

Diagnosis. Body is tubular, basiphytous. Choanosomal spicules are diactins, rarely triactins, stauractins and pentactins which are often fused by synapticula in the lower part of the sponge. Dermalia and atrialia are macrospined pentactins sometimes supplemented with hexactins. Microscleres are graphiocomes and staurasters, with or without calycocome-like oxyhexasters (emended from Tabachnick, 2002).

Atlantisella lorraineae sp. nov.
(Figs 1–4; Table 1)

Material Examined. HOLOTYPE: NIWA 82163: NIWA Stn TAN1206/23, southwest flank of Tangaroa Seamount, southern Kermadec Ridge, 36.336° S; 178.018° E, 1490–1422 m, 17 April 2012. Other Locations (images only): TAN1007/33, Rumble II West, southern Kermadec Arc, 35.347° S; 178.544° E, 1181–1439m, 30 May 2010 (Fig. 2A); TAN0905/54, Diabolical Knoll, Graveyard Hills, northeast Chatham Rise, 42.790° S; 179.987° W, 950 m, 18 June 2009 (from Clark *et al.* 2009) (Fig. 2B); TAN0905/23, north-northeast Graveyard Seamount, Graveyard Hills, northeast Chatham Rise, 42.760° S; 179.961° W, 770–919 m, 15 June 2009 (Fig. 2C–E).

Description. *Shape.* Morphology of the holotype is a large thin-walled funnel with extended foliose edges (Fig. 2, 3A) but since it has no base and the edges of the funnel are broken, the exact form of the entire specimen remains uncertain. Images of living sponges reveal that while some sponges have a funnel-shaped morphology, many form a flattened sheet with foliose margins (Fig. 2A–B). Similarly, some have quite a long hollow peduncle (Fig. 2C) and others a short, hollow peduncle (Fig. 2D).

Dimensions. Entire holotype specimen is 22 mm tall and 31 mm in diameter at the top; the wall is 0.50 (0.26–0.74) mm thick, n=7.

Texture. Flexible but extremely fragile and easily broken. Surfaces are smooth or slightly undulatory, without channelisation.

Colour. In life, pale translucent tan to white, light beige when preserved, wet or dry.

Choanosomal skeleton. A loose spicule network bounded externally and internally by ectosomal membranes (Fig. 3B–C) supported by tangential rays of large spined surficial pentactins. The proximal rays of pentactins of the two surfaces overlap in a network of moderate-size diactins (Fig. 4B). Microscleres are distributed throughout the skeleton.

Ectosomal skeleton. A raised reticulation formed by crossed rays of surficial spined pentactins. Mesh sides of the fairly regularly rectangular dermal lattice are 150 (75–236) µm, n=65, of the less regular atrial lattice are 163 (75–299) µm, n=65. No spicule fusion by synapticula was encountered in the holotype.

Megascleres. (Fig. 4; Table 1): Superficial pentactins, choanosomal diactins and a few tauactins. The superficial pentactins (Fig. 4A) are indistinguishable dermalia and atrialia. Tangential rays are coarsely spined on the external surface and ray tips are simply rounded and finely rough. Overall size of these spicules varies greatly but the proximal ray is always much longer than the tangential rays. The proximal ray is coarsely spined on the half adjacent to the centrum while the distal half is smooth and ends in a finely-rough rounded tip. Diactins (Fig. 4B) are moderate in size and

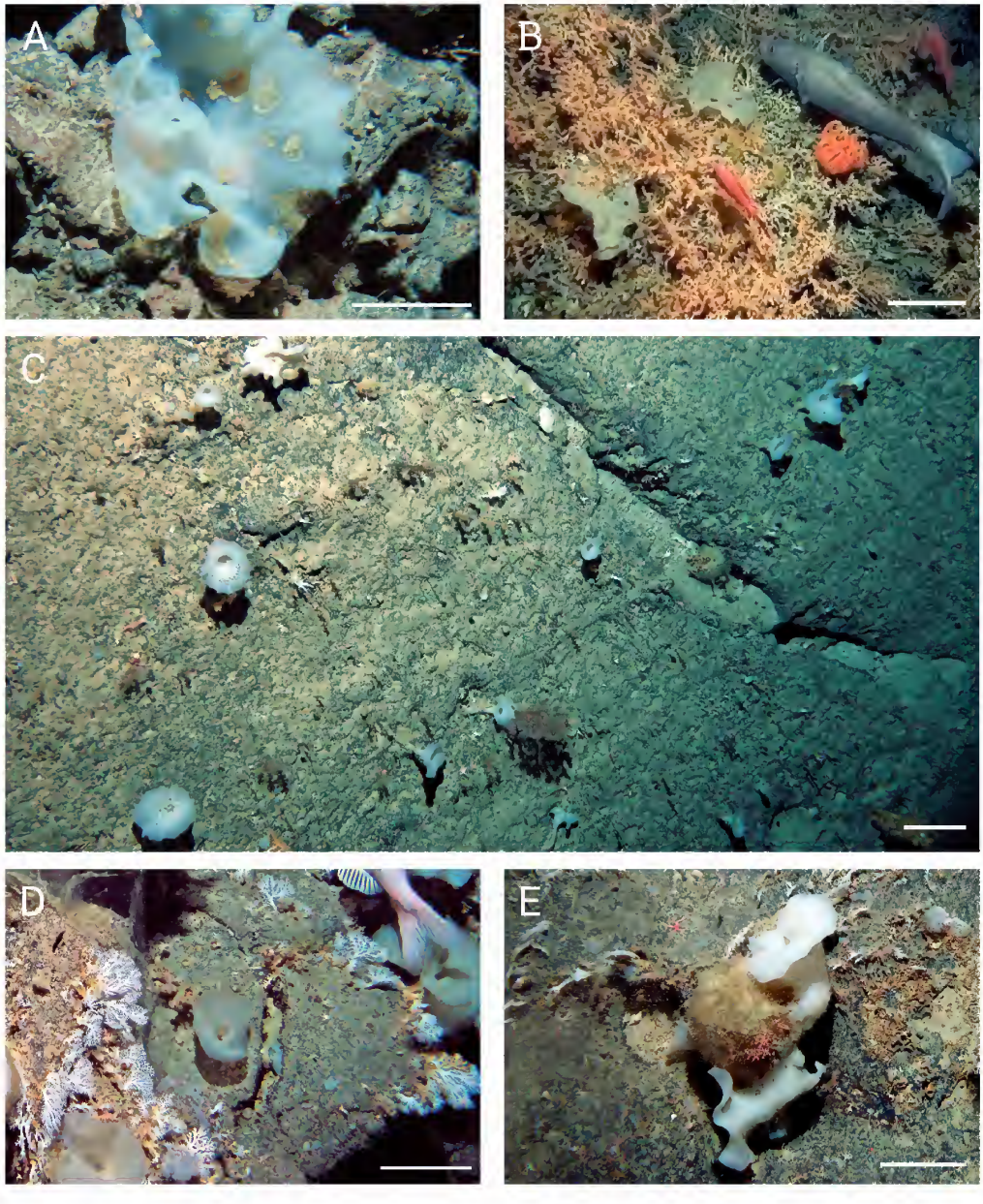

FIG. 2. Images of living *Atlantisella lorraineae* sp. nov. **A**, NIWA Stn TAN1007/33, Rumble II West, southern Kermadec Arc, 1181–1439 m (from Clark *et al.* 2010), scale = 4 cm; **B**, attached to stony coral *Madrepora oculata*, NIWA Stn TAN0905/54, Diabolical Knoll, Chatham Rise, 950 m (From Clark *et al.* 2009), scale = 5 cm; **C**, array of specimens at different stages of maturity, scale = 8 cm; **D**, specimens showing the opening to the hollow peduncle and thin, fine 'weave' of the body, scale = 7 cm; **E**, body wall of these specimens slightly coarser and thicker, possibly a different species, scale = 10 cm. Images captured by DTIS onboard RV *Tangaroa* from NIWA Stn TAN0905/23, Graveyard Seamount, Chatham Rise, 770–919 m (from Clark *et al.* 2009), unless stated otherwise.

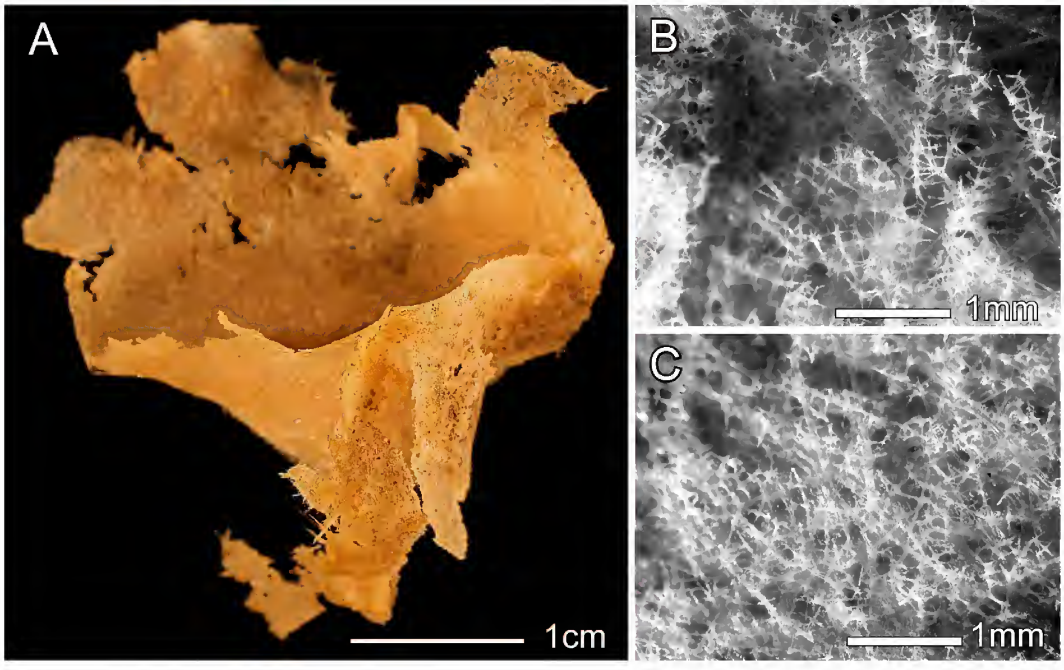

FIG. 3. *Atlantisella lorraineae* sp. nov., holotype NIWA 82163, morphology and skeleton. **A**, body of holotype; **B**, close up of dermal surface; **C**, close up of atrial surface.

TABLE 1. Spicule dimensions (µm) of *Atlantisella lorraineae* sp. nov., holotype NIWA 82163.

Parameter	mean	s.d.	range	no.
Surface macrospined pentactin				
tangential ray length	174	28	99–221	50
tangential ray width	11.8	2.4	6.8–17.1	50
proximal ray length	326	128	163–764	50
proximal ray width	12.7	2.3	8.7–21.0	50
Choanosomal diactin				
length	2228	969	1000–4720	50
ray width of typical diactins	11.3	3.8	5.4–21.0	50
ray width of thicker diactins	26.0	4.6	17.7–41.5	52
Oxystauraster				
diameter	125	12	100–150	50
primary ray length	17.1	2.5	11.7–22.1	50
secondary ray length	45.8	5.2	33.7–58.1	50
Calycocome-like oxyhexaster				
diameter	150	13	122–179	50
primary ray length	16.2	1.9	12.2–20.1	50
secondary ray length	59.4	6.2	48.5–73.5	50
Graphiocome				
centrum diameter	27.6	2.4	19.6–35.7	50
secondary ray (raphide) length	212	18	161–250	50

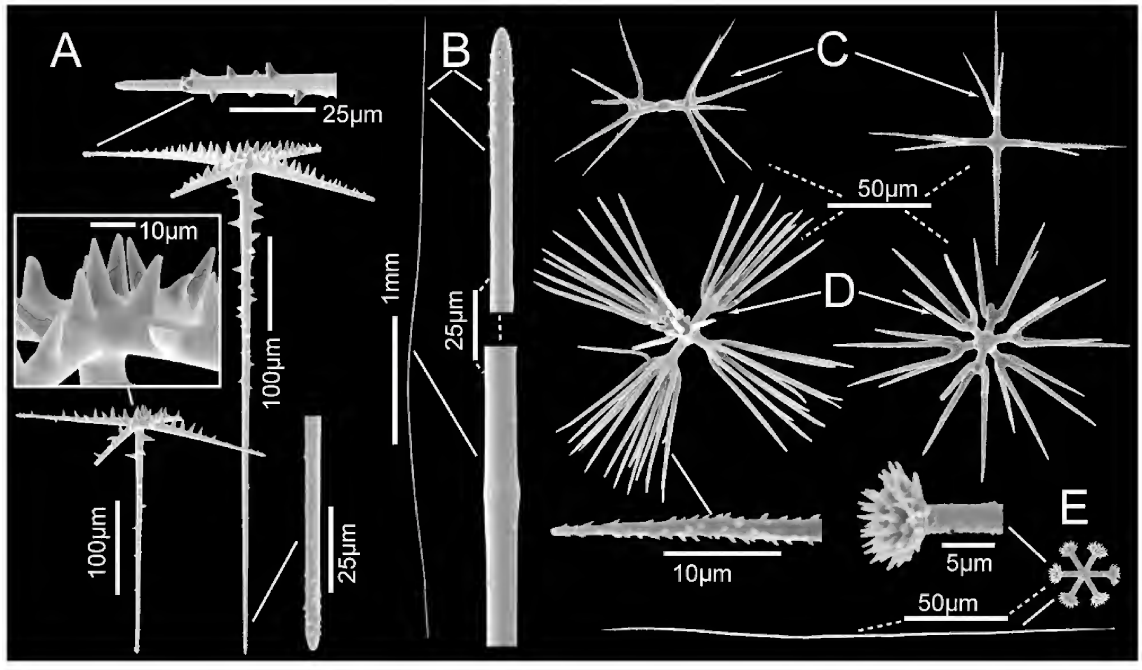

FIG. 4. *Atlantisella lorraineae* sp. nov., holotype NIWA 82163, spicules. **A**, two surficial pentactins, whole and enlarged ray ends and center; **B**, diactin, whole and enlarged end and middle segments; **C**, oxystauraster in side and facial views; **D**, calycocome-like oxyhexasters with differing terminal ray numbers and an enlarged terminal ray end; **E**, graphiocome centrum and loose terminal ray.

divisible into two classes by thickness. Tips are rough and parabolic; the central swelling varies from four distinct knobs to undetectable. Tauactins are rare and physically like the diactins.

Microscleres. (Fig. 4; Table 1): Oxystaurasters, rare hemioxystaurasters, calycocome-like oxyhexasters and graphiocomes. Oxystaurasters (Fig. 4C) and hemioxystaurasters have an ovoid swollen centrum and four primary rays, each of which bears 3 (1–4) pointed terminal rays. The entire spicule is evenly finely-spined and the terminal rays tend to occur in the plane vertical to that of primary rays, giving the spicule an overall high roughness aspect in lateral view but a lower roughness aspect in facial view. The calycocome-like oxyhexasters (Fig. 4D) have a short solid calyx at the distal end of the primary rays, each supporting 4 (3–11) straight terminal rays; this entire spicule is also evenly ornamented with small reclined spines. Unpatterned branching occurs fairly commonly on individual terminal rays. The graphiocome (Fig. 4E) has centrum and primary rays evenly covered with small bumps; each primary calyx supports ~40 smooth straight terminal rays or raphides, 1.2 (1.0–1.4) µm in diameter but devoid of other characters at the resolution limit of the SEM used.

Type Location. Southwest flank of Tangaroa Seamount, southern Kermadec Ridge (Fig. 1).

Distribution. Southern Kermadec Ridge and Chatham Rise, New Zealand.

Substrate, Depth Range, Ecology. The single specimen examined and assigned as holotype was presumably attached to hard substratum but no attachment disc was collected. The depth range for the holotype is 1490–1422 m. Purported images of living specimens indicate that the sponge may attach to hard substrate such as pillow lava outcrops (Fig. 2A) on the southern Kermadec Arc seamounts. These may be sulphur-stained, indicating hydrothermal and venting activity. They also grow on bedrock outcrops (Fig. 2C) with boulder and cobble fields, interspersed with gravel-sand (Clark *et al.*

FIG. 5. Margaret Lorraine Kelly (16 June 1933–1 October 2016). Image by R. Bialostocki, 25 December 2014

2010, 2013). The Graveyard Hills specimens from NIWA Stn TAN0905 grow on sand-overlaid bedrock with gorgonians and corals (Clark *et al.* 2009). Presumed depth range for non-examined specimens is 770–1439 m.

Etymology. The species name *lorraineae* is given in memory of Mrs Lorraine Kelly, the co-author's mother, who died on 1 October 2016, of a long and difficult illness (Fig. 5). Lorraine encouraged, fully supported, and celebrated Michelle's interest in things of the sea, as a young girl in Papua New Guinea, and later, in her academic and field studies.

Remarks. This specimen clearly belongs to genus *Atlantisella* by the diagnosis of Tabachnick (2002). It differs from the only species of the genus, *A. incognita* Tabachnick, 2002 by having no hexactine dermalia, having calycocome-like oxyhexasters among the microscleres (absent in *A. incognita*), and in the form of the oxystauractins (relatively longer primary rays but smaller total diameter in *A. incognita*). These differences are sufficient to conclude that the New Zealand form is the holotype of a new species, here designated *Atlantisella lorraineae* sp. nov. The key diagnostic characters of this species are that the body forms a thin-walled (about 0.5 mm) trumpet with foliose margins, the presence of dermalia and atrialia which are large pentactins coarsely spined on the outer surfaces, and microscleres which include oxystaurasters, calycocome-like oxyhexasters and graphiocomes. Morphological characteristics of *A. lorraineae* sp. nov. and eventually those of the four other widespread and as yet undescribed species will help clarify the position of the genus within the Euplectellidae and the relationships between the other genera in the eventual taxonomic revision of the family.

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Studies on Southwest Pacific Hexactinellida 2: two new hexactinosid glass sponges from the Norfolk Ridge (New Caledonia EEZ)

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ABSTRACT

Two new hexactinosid dictyonal glass sponges (Class Hexactinellida Schmidt, Order Hexactinosida Schrammen) are described from Seamount Banc Antigonia on the southern New Caledonian slope of the Norfolk Ridge. *Heterorete norfolkense* sp. nov. (Family Euretidae Zittel) shares many characters with the type species, *Heterorete pulchrum* Dendy, 1916, from north-central Indian Ocean, but the Norfolk Ridge specimens have thinner walls, smaller diameter tubes, loose surface pentactins (absent in *H. pulchrum*, uncommon in *H. norfolkense* sp. nov.) and two classes of discohexasters (vs 1 class in *H. pulchrum*). This new species is only the second known world-wide and represents a new genus record for the region. *Cyrtaulon caledoniensis* sp. nov. (Family Tretodictyidae Schulze) differs significantly in the form and dimensions of some of the spicules from the western tropical Atlantic type species, *C. sigsbeei* (Schmidt, 1880) and *C. solutus* Schulze, 1886 from the Banda Sea, Indonesia. The species also represents a first record of the genus for the South Pacific and only the third known species world-wide. ❐ *Hexactinellida, Hexactinosida, Euretidae, Tretodictyidae, Cyrtaulon, Heterorete, systematics, Norfolk Ridge, New Caledonian EEZ.*

A detailed examination of six tiny specimens in two specimen holding jars from the Queensland Museum, provisionally identified as *Farrea occa occa* Bowerbank, 1862 (Order Hexactinosida Schrammen, Family Farreidae Gray), revealed to the contrary, the New Zealand species *Farrea medusiforma* Reiswig & Kelly, 2011 and two new species, one of *Heterorete* Dendy, 1916 (Order Hexactinosida, Family Euretidae Zittel) and the other of *Cyrtaulon* Schulze, 1886 (Order Hexactinosida, Family Tretodictyidae Schulze), previously only known from Salomon Atoll in the Chagos Archipelago, Indian Ocean and the western tropical Atlantic and Indonesia's Banda Sea, respectively. The specimens were collected from IRD (Institut de Recherche pour le Développement, New Caledonia) Station CP1655 on Seamount Banc Antigonia on the south New Caledonian slope of Norfolk Ridge, providing two new genus records for the south Pacific region. Here we describe only the second known species of *Heterorete, H. norfolkense* sp. nov., comparing it to the genus type *H. pulchrum* Dendy, 1916 and the third known species of *Cyrtaulon, C. caledoniensis* sp. nov.

MATERIAL AND METHODS

Two Queensland Museum holdings, QM G318665 and QM G318547, were examined as part of a wider study of the hexactinellid sponges of the New Zealand and South Pacific region. They were collected as part of the Institut de Recherche pour le Développement, Noumea "*Norfolk 1*" and "*Norfolk 2*" voyages by RV *Alis*, led by Bertrand Richer de Forges, in 2001. Sponges collected on the voyages were sent to the Queensland Museum for identification, and the hexactinellid sponges were sent on loan to Dorte Janussen in 2004. The material was collected by seamount dredge from IRD Stn CP1655, Seamount Banc Antigonia on the south New Caledonian slope of Norfolk Ridge, part of the New Caledonian Exclusive Economic Zone (EEZ) (Fig. 1). Specimens were either frozen at -10°C or preserved in 95% ethanol, and later transferred to 70% ethanol.

The two specimens in QM G318665 were assigned to the holotype of *Heterorete norfolkense* sp. nov. One of four specimens in QM G318547 (fragment C) was also identified as *H. norfolkense* sp. nov. As both QM registrations G G318665 and G318547 are from the same IRD station, we have assumed that they are both from the same haul and thus QM G318547 (fragment C) is part of the *H. norfolkense* sp. nov. holotype specimen. The holding QM G318665 now contains three specimens. Two of the four specimens in QM G318547 were identified as *Farrea medusiforma*; these were removed from QM G318547 and re-accessioned as QM G331810. The final specimen in QM G318547, was identified as *Cyrtaulon caledoniensis* sp. nov. and retains that accession number QM G318547 and is named as holotype.

Specimens were first digitally photographed and fragments were digested in commercial sodium hypochlorite bleach. These preliminary examinations usually provided information on spicules, structure of the frameworks, presence or absence of channelisation, and type of nodes present. Wall sections about 0.5 mm^2 were excised, dehydrated, cleared, and whole mounted in Canada Balsam on microscope slides.

Preparations of cleaned spicules and dictyonal frameworks were made by taking one or two 0.5–1.0 ml subsamples from a specimen, soaking them in water to remove ethanol, then digesting them in test tubes in hot (95° C) nitric acid to dissolve organic contents from spicules and frameworks. After cooling and diluting in a small petri dish, frameworks and large spicules were picked from the suspension by forceps or pipette under a dissecting microscope, repeatedly rinsed in distilled water, and transferred either directly to clean 9 mm square cover glasses or to cover glasses coated with hot glue (tacky at 42° C), double-sided tape or epoxy. The cover glasses were attached to scanning electron microscopy (SEM) stubs by epoxy.

The clean spicules remaining in the diluted nitric acid suspension were further processed for both light microscopy (LM) and SEM. Large spicules were rinsed in water and transferred by pipette onto microscope slides and spread out with forceps and needle. After drying, Canada Balsam and cover glasses were added. A small aliquot of the remaining spicule suspension was passed through a 13 mm diameter, 0.2 µm pore-size polycarbonate membrane filter, the filter air-dried and mounted on an SEM stub using double-sided tape. The remaining spicules in suspension were deposited on three or four 25 mm diameter, 0.22 µm pore-size nitrocellulose Millipore© filters by vacuum filtration, the filters dried and mounted on slides in Canada Balsam. The dry SEM preparations were sputter-coated with gold-palladium and imaged with a Hitachi S-3500 SEM at the Biology Department, University of Victoria.

Measurements of spicules were made using a digitiser optically coupled to either compound or dissecting LM by drawing tube (camera lucida) and Sigma-Scan® software. Framework elements were either measured directly by LM as above, or indirectly by using the image-analysis software SigmaScan Pro® on the SEM images. Dimensions are given in a table associated with the 'Description' section for each species. Dimensions are cited as mean (mean) and standard deviation (s. d.), range, and the number of measurements made (no.).

Primary type material of the new species are deposited in the Queensland Museum and accessioned into their biodiversity collections (prefix QM G—). Abbreviations used in the text: EEZ, Exclusive Economic Zone; IRD, Institut de Recherche pour le Développement, Noumea, New Caledonia; LM, light microscopy; NHMUK, prefix to registration numbers for the Natural History Museum, London; No., number of measurements made; QM G, accession prefix for Queensland Museum biodiversity collections, Brisbane; SEM, scanning electron microscopy; s.d., standard deviation.

SYSTEMATICS

Class HEXACTINELLIDA Schmidt, 1870

Order HEXACTINOSIDA Schrammen, 1903

Family EURETIDAE Zittel, 1877

Heterorete Dendy, 1916

Heterorete Dendy, 1916: 214.

Type Species. *Heterorete pulchrum* Dendy, 1916 (by original designation).

Diagnosis. Euretidae with body form of branching, thick-walled tubes terminally open as oscula (anastomoses sometimes uncertain); with epirhyses and aporhyses (questionable) penetrating nearly the entire wall; dictyonal framework profusely and coarsely spined and consisting of two distinct regions – a main euretoid network of normally thick beams forming irregular triangular and rectangular meshes and an atrial network of thin, loosely-fused hexactins with junctions occurring at ray-crossing points and most rays remaining free (closed meshes mostly lacking); nodes not swollen; loose ectosomal spiculation consists of discohexasters with or without rare pentactins; choanosomal spiculation of spined oxyhexactins and regular and irregular discohexasters. Proper sceptrules and uncinates are absent (emended from Reiswig & Wheeler 2002).

Heterorete norfolkense sp. nov.
(Figs 1–3; Table 1)

Material Examined. HOLOTYPE: QM G318665, IRD Stn CP1655, Seamount Banc Antigonia, south New Caledonian slope of Norfolk Ridge (New Caledonian EEZ), 23.524° S, 168.076° E, 680 m, 19 June 2001, RV *Alis*. NORFOLK 1 voyage, coll. Bertrand Richer de Forges, 3 fragments (Fig. 1). Comparative Material. *Heterorete pulchrum*, holotype, NHMUK 1920.12.9.64: H.M.S. *Sealark*, Stn C, Salomon Atoll, Chagos Archipelago, Indian Ocean, 4.170° S, 92.020° E, 220–274 m, 03 July 1905.

Description. *Shape*. The holotype consists of three fragments (Figs 2A–B), each a spherical network of loosely branching and anastomosing broad and wide-mouthed tubes, one of which is attached to the calcareous skeleton of a bryozoan.

Dimensions. Holotype fragments are 1) 37.8 long x 32.0 wide x 17.2 mm thick; 2) 35.4 long x 28.6 wide x 15.7 mm thick; 3) 31.6 long x 24.0 wide x 19.8 mm thick. Tubes are slightly oval, 5.5 x 6.0 mm diameter, (range 3.7–8.3, n=57) with wall thickness of 0.9 ± 0.2 (0.4–1.4) mm, n=63. Intercanals have the same dimensions as the tubes.

Texture. Hard and moderately resistant to breakage. Surface of both inner and outer wall sides are smooth to the naked eye but when inspected at low magnification of a dissecting microscope, both are covered with small openings of shallow canals, epirhyses on the dermal side and aporhyses on the atrial side (Fig. 2C, D). With higher magnification, large discohexasters are seen standing out on dictyonal prominences of the dermal surface (Fig. 2E).

Colour. Light beige when preserved, wet or dry.

Ectosomal skeleton. Consists of free spicules: surficial pentactins, uncinates (probably foreign), and two sizes of discohexasters.

Choanosomal skeleton. A fused dictyonal network of rather irregular construction. Throughout the thickness of the wall (Fig. 2F) and on the dermal surface (Fig. 2G–I) the beams are rather uniform in thickness and nodes are simple. Meshes are triangular and rectangular but there is no suggestion of longitudinal strands. Frame nodes inspected in 80% sucrose showed most have a single axial cross (48 of 59)

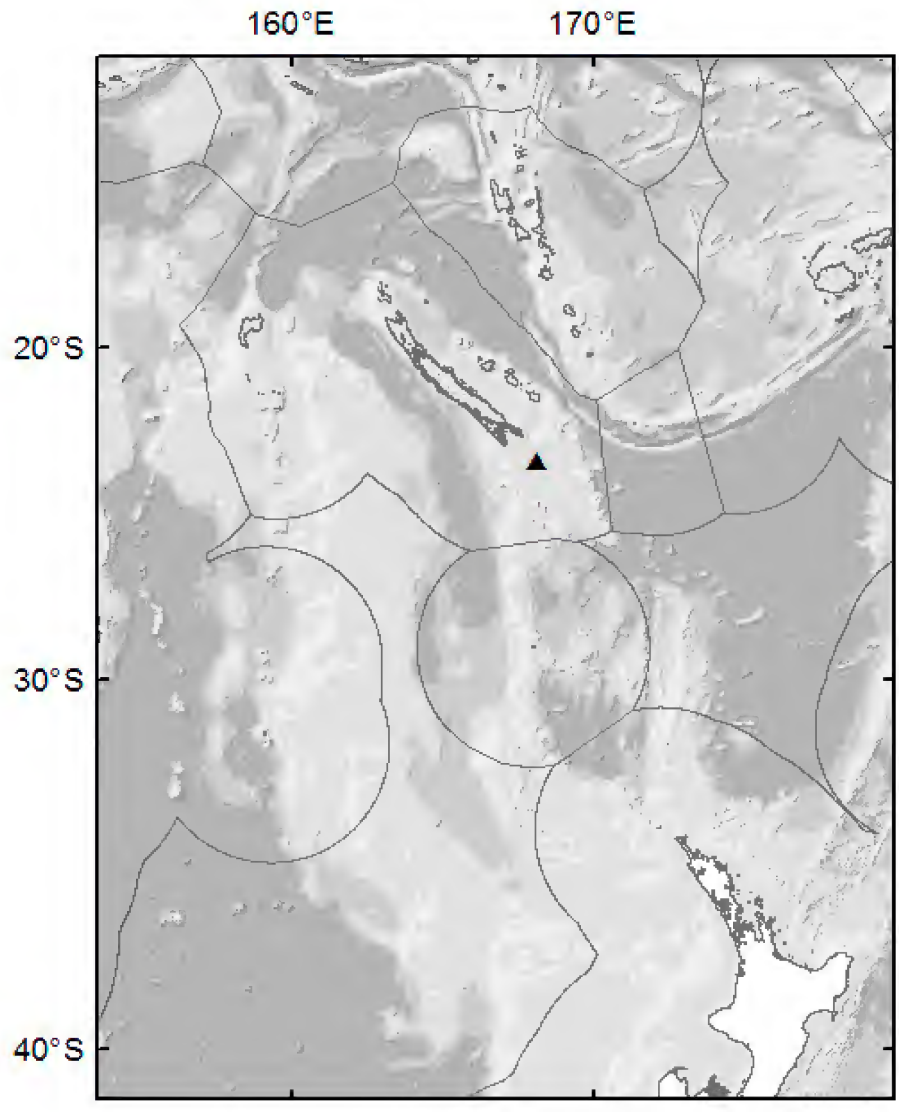

FIG. 1. Study area showing the collection locality of the holotype of *Heterorete norfolkense* sp. nov. and *Cyrtaulon caledoniensis* sp. nov., Seamount Banc Antigonia on the southern New Caledonian slope of Norfolk Ridge.

but several (11 of 59) contained two axial crosses. Synapticula with and without axial canals are common. The atrial surface has a patchy development (Fig. 2J–L) of bushes of small thin hexactins forming candelabras (groups of free rays without attachments). These appear to be stable elements that do not undergo thickening since they occur over all of the atrial surface of the specimen. Small patches of smaller spiny oxyhexactins are found scattered through the framework, fused to each other and onto beams. Some of these have all six rays intact and appear to be components of the free spicule complement. In addition, there are free uncinates (probably of foreign origin) and discohexasters in the endosome.

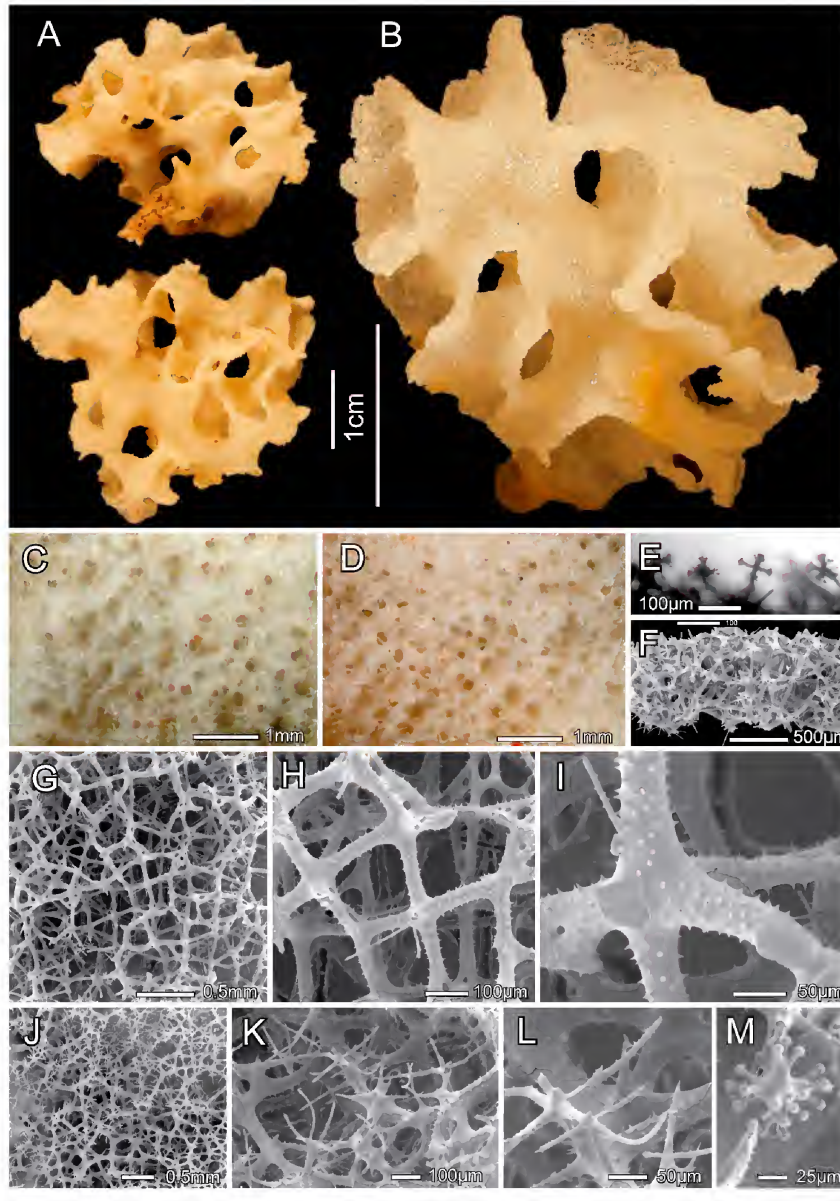

FIG. 2. *Heterorete norfolkense* sp. nov., holotype QM G318665. **A–B**, holotype as three fragments presumed to be from the same specimen; **C**, close-up of dermal surface of holotype showing epirhyses; **D**, close-up of atrial surface of holotype showing aporhyses; **E**, tangential surface view of dermal surface of holotype with discohexasters on framework prominences; **F**, wall section of the cleaned skeletal framework of holotype; **G**, cleaned framework of the dermal surface of holotype with indistinct epirhyses; **H**, closer view of dermal framework of holotype showing spurs and relatively simple beams; **I**, closer view of dermal dictyonalium of holotype with small, sharp conical spines on beams and nodes; **J**, atrial framework of holotype at low magnification showing patchy distribution of small dictyonalia; **K**, closer view of the fine atrial dictyonalia with curved rays; **L**, closer view of the atrial dictyonalia and its contrast with the normal framework beams in the background; **M**, discohexaster fused onto the framework.

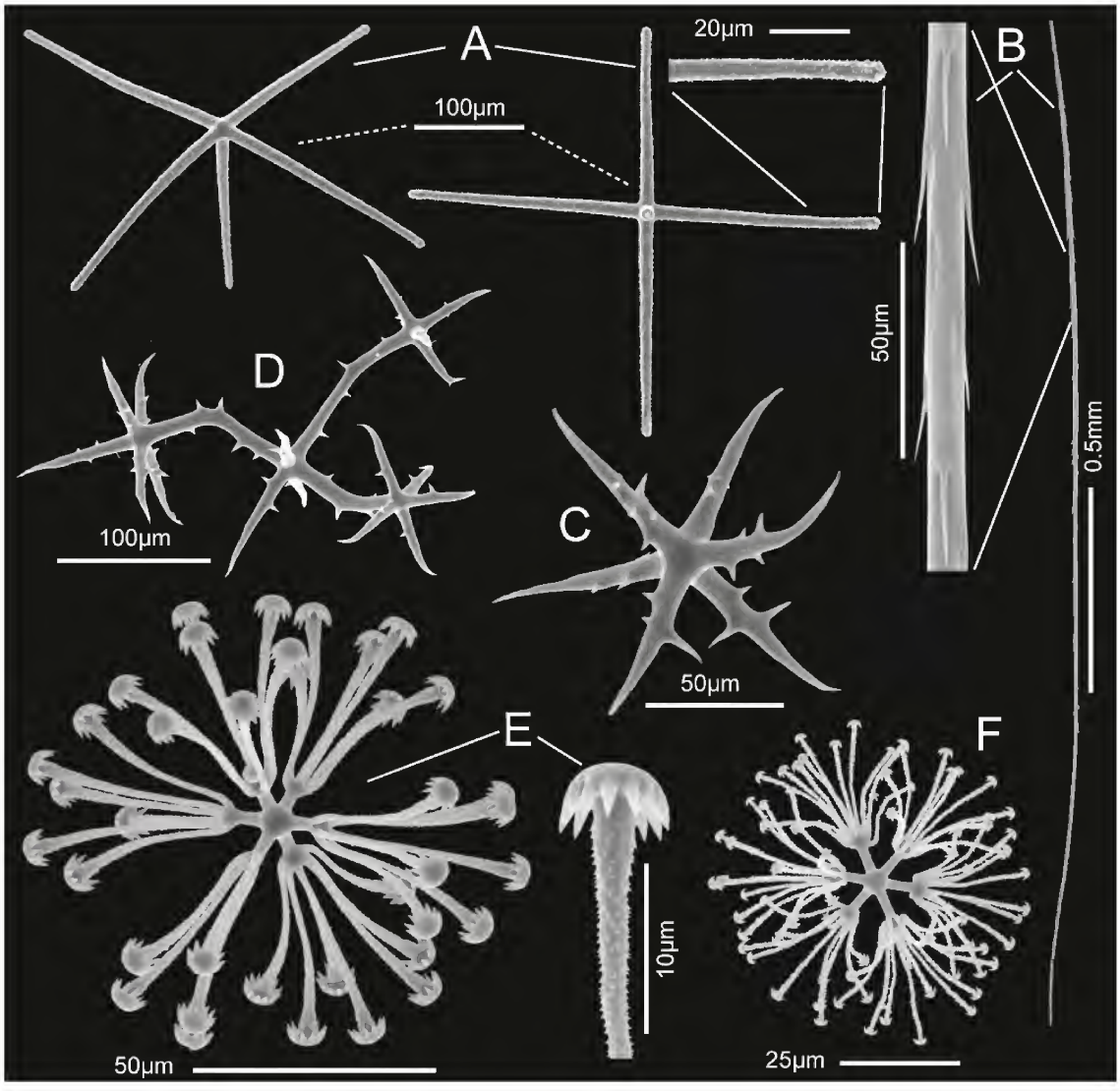

FIG. 3. *Heterorete norfolkense* sp. nov. holotype QM G318665, spicules. **A**, two surficial pentactins, whole and enlarged tangential ray end; **B**, uncinate (almost certainly foreign), whole and enlarged anterior segment; **C**, spiny microxyhexactin; **D**, spiny microxyhexactins fused together and fused to the skeletal framework; **E**, large discohexaster with enlarged secondary ray end; **F**, small discohexaster.

Megascleres. (Fig. 3; Table 1): Restricted to uncommon surficial pentactins and uncinates (probably foreign). Pentactins (Fig. 3A) are entirely finely rough with cylindrical rays ending in rounded tips. The proximal rays are usually shorter than the tangential rays, but intact spicules are hard to find. Uncinates (Fig. 3B) are moderate in size and have no special characters; brackets and barbs are well developed and barb inclination is slight.

Microscleres. (Fig. 3; Table 1): Microxyhexactins and two sizes of floricate discohexasters. Microxyhexactins (Fig. 3C) are small but thick-rayed, bearing a few large spines on each of the

otherwise smooth rays. Groups of very similar spicules are encountered fused to each other and to the framework dictyonalia, suggesting that their joining is a secondary process taking place after the spicule is completely formed (Fig. 3D). Large discohexasters (Fig. 3E) have weakly sigmoid rays in floricate tufts; they could be characterised as spherical or pseudostellate. Primary rays are smooth but secondary rays are densely covered with sharp small reclined spines; terminal discs are hemispherical and bear 10–15 sharp marginal spines. Small discohexasters (Fig. 3F) are very similar to the large ones but the terminal rays are relatively thinner and more strongly sigmoid and their primary rays are proportionately longer. Their terminal discs contain 6–10 marginal spines.

Type location. Seamount Banc Antigonia, south New Caledonian slope of Norfolk Ridge (Fig. 1).

Distribution. Known only from the type locality.

Substrate, depth range, ecology. Attached to hard substratum by siliceous attachment disk, depth 680 m.

Etymology. The species name *norfolkense* reflects the general type locality, the Norfolk Ridge south of New Caledonia.

Remarks. The three fragments from the Norfolk Ridge have skeletons compatible only with the genus *Heterorete*, with the type species *H. pulchrum*, from north-central Indian Ocean as the only member. The new fragments share many characters with *H. pulchrum*, including sizes of framework beams and meshes, distinctive atrial framework, surface pits, simple nodes, framework spines, stout oxyhexactins, floricoid discohexaster and their occasional fusion onto the atrial framework (Fig. 2M). The key differences are, however, that the New Caledonian specimens have thinner walls (0.9 vs 2.0 mm), smaller diameter tubes (6 mm vs 8 mm), loose surface pentactins (absent in *H. pulchrum*), uncinates (absent in *H. pulchrum* but also probably not proper here) and two classes of discohexasters (vs 1 class in *H. pulchrum*). The pentactins and uncinates could be explained by their transfer from other specimens, *Farrea medusiforma* and *Cyrtaulon caledoniensis* sp. nov., collected in the same

TABLE 1. Spicule dimensions (µm) of *Heterorete norfolkense* sp. nov., holotype QM G318665.

Parameter	mean	s.d.	range	no.
Surficial pentactin				
tangential ray length	195	25	136–271	69
ray width	10.2	2.9	4.6–19.0	72
proximal ray length	127	31	64–177	19
ray width	10.5	2.7	6.0–17.0	20
Uncinate length	1678	518	333–2387	20
width	7.5	1.7	3.1–11.1	24
Spined oxyhexactin diameter	106	35	33–173	31
Large discohexaster diameter	96.5	11,2	70.9–126.0	143
primary ray length	8.1	1.1	5.5–10.8	143
secondary ray length	40.1	5.1	26.6–53.7	143
ratio 1°/2° ray length	0.204	0.033	0.131–0.371	143
Small discohexaster diameter	62.7	10.4	36.4–86.2	89
primary ray length	8.5	1.2	6.0–11.6	89
secondary ray length	23.0	5.0	11.6–32.4	89
ratio 1°/2° ray length	0.389	0.100	0.201–0.692	89

trawl. However, comparison of the form and sizes of the pentactins of those specimens with those of *H. norfolkense* sp. nov. shows that they are not the source, but the uncinates could be from either species; thus the pentactins appear to be proper although uncommon. Neither pentactins nor uncinates were found in whole mounts of fragments although microscleres were common. Absence of the pentactins in these preparations is understandable since they are rare and easily lost during manipulation of the specimen. Absence of uncinates, the spicule most resistant to loss, is strong evidence that those found in spicule preparations are foreign in origin.

The two size classes of discohexasters in *H. norfolkense* sp. nov. are not supported by frequency distribution of their diameters, but this does not negate that two classes exist here. Their difference is in the degree of robustness, the degree of curvature of secondary rays and the numbers of marginal spines of terminal discs. A quantitative approach to assess shape is the ratio of lengths of primary to secondary rays; in *H. norfolkense* sp. nov. the means of this ratio are 0.205 and 0.382 for the two classes of discohexasters. In *H. pulchrum*, however, there is no obvious difference in form among the highly variable sizes of discohexasters, but if two types were present we would expect there would be differences in the ratios of the largest and smallest discohexasters. We took the smallest and largest 10 of 50 discohexasters and determined their ray ratios: 0.227 and 0.306 respectively. There appears to be a shape difference between the small and large discohexasters in *H. pulchrum* but it is not as great as in *H. norfolkense* sp. nov. and does not approach the very long primary rays seen in the smaller discohexasters of the Norfolk Ridge sponge. The two known species are broadly separated: *pulchrum* is from Salomon Atoll in the Indian Ocean while *norfolkense* sp. nov. is from the Norfolk Ridge in the South Pacific. Locality, morphology (wall thickness) and spicule differences (surface pentactins) are sufficient to conclude that *H. norfolkense* sp. nov. is a unique species and only the second known for the genus.

Family TRETODICTYIDAE Schulze, 1886

Cyrtaulon Schulze, 1885

[*Volvulina*] Schmidt, 1880: 58 (preoccupied).
Cyrtaulon Schulze, 1886: 81; Schulze, 1887: 332, Pl. 92.

Type species. *Volvulina sigsbeei* Schmidt, 1880.

Diagnosis. Body cup-form or cylindrical without atrial cavity; superficial dictyonal nodes and beams may be hypersilicified (swollen) or not; dermalia as pentactins, with or without hexactins; regular scopules may or may not be present; medium-sized uncinates present, with or without a central swelling; in addition to the 'cyrtaulon-spicule', there are only discohexasters or no other microscleres present (Reiswig, 2002).

Cyrtaulon caledoniensis sp. nov.
(Figs 1, 4–5; Table 2)

Material examined. HOLOTYPE: QM G318547, IRD Stn CP1655, Seamount Banc Antigonia, south New Caledonian slope of Norfolk Ridge (New Caledonian EEZ), 23.524° S, 168.076° E, 680 m, RV *Alis*. NORFOLK 1 voyage, coll. Bertrand Richer de Forges, 19 June 2001.

Description. *Shape*. Morphology of the holotype a moderate-size blockish convoluted fragment perforated with small passages (Fig. 4A–B) from a dictyonal sponge with unknown total body form, perhaps conical or foliose, but is not constructed of component tubes. Two zoanthids occupy passages through the wall.

Dimensions. Holotype 13.9 long x 13.3 wide x 10.1 mm thick. The wall is 0.83 ±0.16 (0.64–1.15) mm, n=14 thick and completely penetrated by ovoid holes much larger in diameter than wall thickness, 2.1 x 1.7 mm (range 1.0–4.7, n=28) but extending down to minute passages (Fig. 4C).

Texture. Hard and rigid. Surface appears by eye and dissecting microscope as if composed of thick lumpy beams between large spaces (Fig. 4C).

Colour. Light beige to white depending upon immersion fluid and light source intensity (Fig. 4A–B).

Ectosomal skeleton. Composed of loose spicules; pentactins, cyrtaulon-spicules and uncinates (in part). Two forms of microscleres are also present here since they are generally distributed.

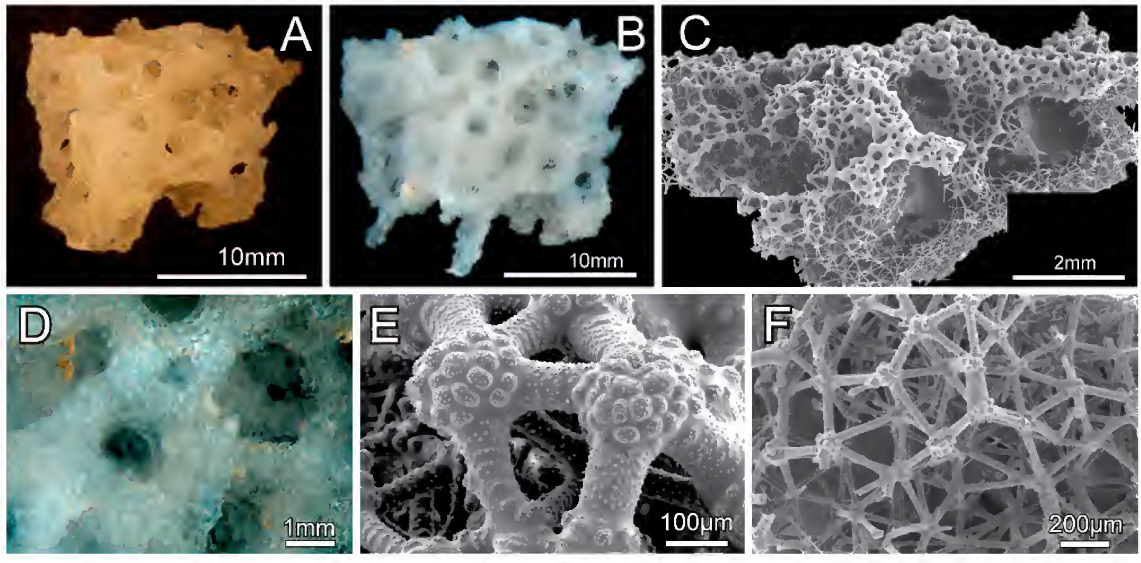

FIG. 4. *Cyrtaulon caledoniensis* sp. nov. holotype QM G318547. **A**, holotype after subsampling; **B**, holotype before subsample under different illumination; **C**, close up showing rough texture of beams between wall holes; **D**, wall fragment with perforations and thickened external frame surface; **E**, close view of swollen, warty external (dermal) nodes and thickened beams; **F**, surface nodes of the internal (atrial) and internal wall nodes and thin beams.

Choanosomal skeleton. Consists of a fused dictyonal framework on which the beams and nodes are thickened on one side (Fig. 4D), presumably the dermal or external surface; the nodes of this side are covered in large warts and finely spined while the beams bear small spines often arranged in transverse bands (Fig. 4E). Spurs are rare on this surface due to a combination of their being subsumed by silica deposition during beam thickening and by this surface being more exposed to erosion. Beams and nodes of the other side, presumably atrial and internal, are smaller (Fig. 4F) and similar to the deeper internal parts of the framework where thickening has not occurred. Meshes are mainly triangular, rarely rectangular or polygonal; most nodes are polyradial and their arrangement is rotular, without evidence of longitudinal strands or nodal ranking. Dimensions of the beams and nodes of the two surfaces are given in Table 2. Loose spicules associated with the endoskeletal framework are large uncinates and the generally distributed microscleres.

Megascleres. (Fig. 5; Table 2): Restricted to three types - surficial pentactins, cyrtaulon-spicules and uncinates. The surficial pentactins (Fig. 5A) are moderate in size, entirely finely rough with cylindrical rays (not tapering) ending in slightly inflated rounded tips. A distinct lattice formed by these spicules has not been found, instead they occur in low numbers between surface nodes where they were moved during collection. In minimally disturbed specimens a distinct lattice of pentactins may occur on both sides. Cyrtaulon-spicules are here considered analogs of scopules and thus categorised as megascleres. The cyrtaulon-spicules (Fig. 5B) have a small swollen head at the top of the long filiform rachis (stem). The head supports 9.3 (4–15), n=50 rather straight rays ornamented laterally by recurved spines and capped by anchorate discs with 7 (3–10+), n=31 long marginal teeth; abnormal discs with subdivided teeth or tufts of short spines occur uncommonly. Branching of the short upper rays is rare and occurs only near their attachment to the head. The rachis is ornamented only by a few scattered recurved spines and is subterminally inflated above a short terminal process. Proper scopules are absent. The uncinates are of moderate size with

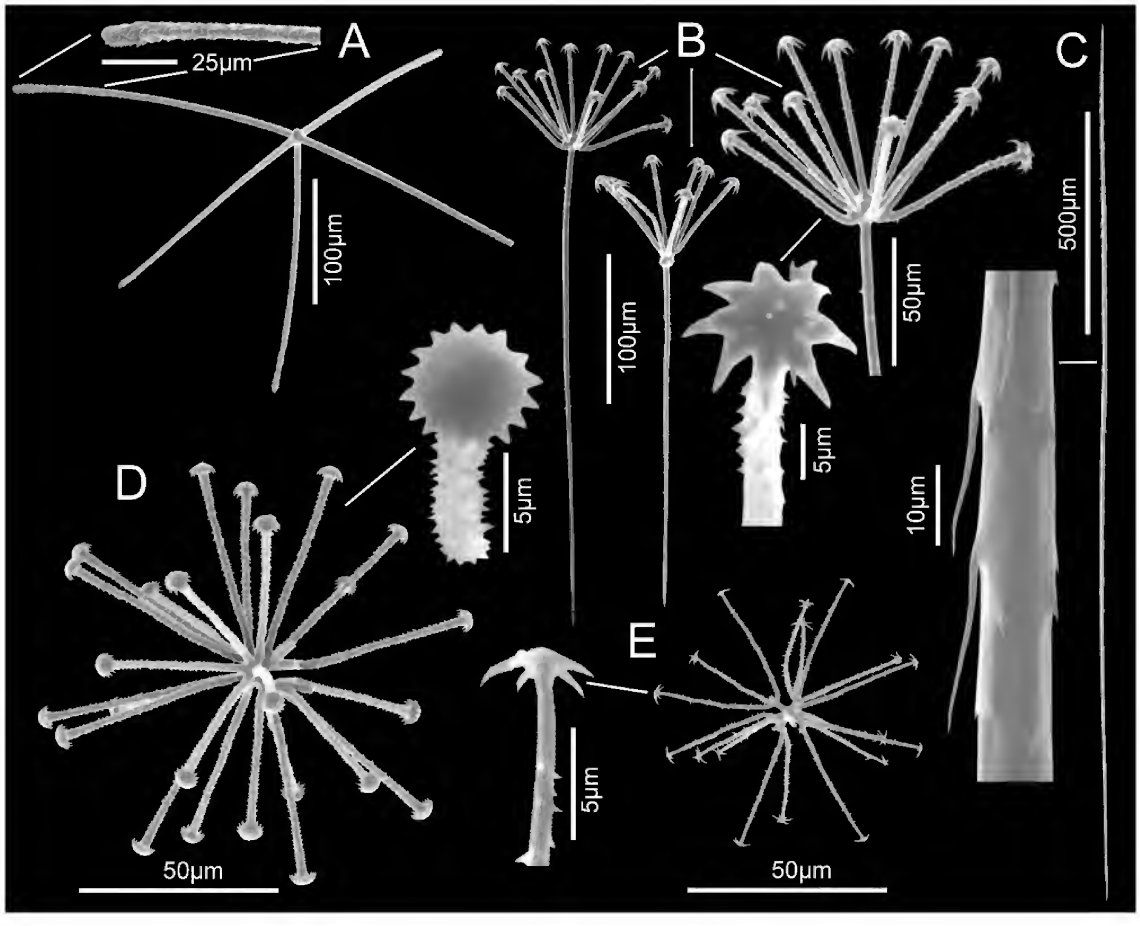

FIG. 5. *Cyrtaulon caledoniensis* sp. nov., holotype QM G318547, spicules. **A**, surficial pentactin, whole and enlarged tangential ray end; **B**, cyrtaulon-spicules, whole, enlarged distal end and further enlarged anchorate disc tip; **C**, uncinate, whole and enlarged upper segment; **D**, discohexaster with enlarged pileate disc tip; **E**, onychohexaster with enlarged anchorate tip.

well-developed brackets and barbs (Fig. 5C); barbs are inclined about 10° from the uncinate surface. Dense populations of microuncinates are absent.

Microscleres. (Fig. 5; Table 2): Discohexasters and onychohexasters. Discohexasters (Fig. 5D) are spherical with very short or even unmeasurable primary rays and long straight cylindrical secondary rays densely ornamented laterally with small reclined spines and ending in a hemispheric pileate disc with about 17 small marginal teeth. Onychohexasters (Fig. 5E) are similar in dimensions but compared to the discohexasters, they are generally slighter, have sparser lateral spine ornamentation and have anchorate tips without a significant central swelling; terminal claws range from 3–6.

Type location. Seamount Banc Antigonia, southern New Caledonian slope of Norfolk Ridge (Fig. 1).

Distribution. Known only from the type locality.

Substrate, depth range, ecology. Presumed to have been attached to hard substratum by siliceous basal disc but not present in the fragment collected, depth 680 m.

Etymology. The species name *caledoniensis* reflects the type locality region, the New Caledonia EEZ.

TABLE 2. Framework and spicule dimensions (µm) of *Cyrtaulon caledoniensis* sp. nov., holotype QM G318547.

Parameter	mean	s.d.	range	no.
External swollen framework				
node diameter	189	24	140–269	50
beam length	288	52	164–426	50
beam width	92	2-	56–147	50
spur length	172	41	120–275	28
Internal less-swollen framework				
node diameter	83	14	49–117	50
beam length	260	50	173–378	50
beam width	30.7	5.4	20.7–43.1	50
spur length	135	40	54–245	50
Pentactine surfalia				
tangential ray length	205	35	130–280	50
ray width	5.6	1.2	3.5–8.4	50
proximal ray length	185	55	95–391	50
ray width	5.5	0.9	4.0–8.0	50
Cyrtaulon-spicule total length	341	41	215–423	50
primary ray length	70.8	8.1	53.3–88.7	50
shaft width at top	4.3	0.8	2.2–6.2	50
Uncinate length	1542	556	360–2567	50
width	7.4	2.3	2.4–11.8	50
Discohexaster diameter	105	11	85–131	50
primary ray length	4.3	0.8	3.0-6.4	50
secondary ray length	48.5	5.7	38.2–60.7	50
Onychohexaster diameter	101	13	62–123	50
primary ray length	4.4	0.6	3.0–5.4	50
secondary ray length	46.7	8.7	21.7–64.8	50

Remarks. Assignment of QM G318547 to the genus *Cyrtaulon* is certain based upon the presence of special cyrtaulon-spicules and no other character precluding membership in Tretodictyidae. The genus *Cyrtaulon* presently contains two species, *C. sigsbeei* (Schmidt 1880) in the tropical western Atlantic and *C. solutus* Schulze, 1886 from the Banda Sea, Indonesia. The new form shares the perforated body wall, the swollen and warty superficial external framework nodes, and surface pentactins with *C. sigsbeei* but differs from this in larger cyrtaulon-spicule (215–423 vs 184–271 µm length), rare branching of the distal rays of cyrtaulon-spicules, larger uncinate [1542 (350–2567) vs 941 (737–1142) µm length], larger discohexaster [105 (85–131) vs 43 (33–60) µm diameter], and presence of onychohexasters (absent in *C. sigsbeei*). *Cyrtaulon caledoniensis* sp. nov. differs from *C. solutus* in its lack of proper scopules and lack of microuncinates and presence of both discohexasters and onychohexasters (both lacking in *C. solutus*). On the basis of these significant differences from both of the accepted species, the New Caledonian specimen is considered a member of a new species, here designated *Cyrtaulon caledoniensis* sp. nov.

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A significant range extension of the unbanded shovel-nosed snake (*Brachyurophis incinctus* Storr, 1968) in the Einasleigh Uplands

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ABSTRACT

Until now there have been two species of burrowing elapid from the genus *Brachyurophis* known to occur in the Einasleigh Uplands Bioregion of northeastern Queensland, the Australian coral snake (*Brachyurophis australis* Krefft, 1864) and the north-eastern (or Campbell's) shovel-nosed snake (*Brachyurophis campbelli* Kinghorn, 1929). Here we report a third species from the region, the unbanded shovel-nosed snake (*Brachyurophis incinctus* Storr, 1968). This is significant because it is the most north-easterly known occurrence of this species in Australia, adds to the known biodiversity of the region and extends the species' known range by more than 400km to the northeast. ❒ *range extension;* Brachyurophis*; shovel-nosed snake; Einasleigh Uplands*

Elapid snakes of the genus *Brachyurophis* are widely distributed throughout mainland Australia (Wilson & Swan 2013). *Brachyurophis* is a group of eight small (<400 mm total length; TL), oviparous elapid snakes of moderately robust build (Greer 1997; Cogger 2014). They are small-eyed, slow-moving snakes, and most species possess a sharply tipped rostral scale that assists in pushing through loose substrates (Shine 1984; Greer 1997; Wilson & Swan 2013). Members of the genus *Brachyurophis* are secretive, semi-fossorial snakes, and their surface activity is typically nocturnal (Shine 1984; Wilson & Swan 2013). Some *Brachyurophis* species feed exclusively on reptile eggs, while others will also take skinks (Scanlon & Shine 1988; Goodyear & Pianka 2008; Cogger 2014).

Brachyurophis incinctus (Storr 1968 [1967 *on title page*]) averages 300 mm TL and scale counts are: 140–165 ventrals; 15–17 midbody; 18–30 divided subcaudals; with a divided anal scale (Cogger 2014). The rostral scale is acutely tipped. The colouration of *B. incinctus* varies from pink to brown with a black interorbital blotch on the head, a broad black nuchal bar and no banding on the body (Horner 1998; Wilson 2015). *Brachyurophis incinctus* is easily identifiable from all known congeners that occur in Queensland (QLD) by the lack of banding on its body (Wilson 2015). *Brachyurophis incinctus* is distinguished from the only other unbanded *Brachyurophis*, *B. morrisi* (Horner 1998), by having a smaller combined ventral/subcaudal count (159–161 *vs.* 166–197) and by having only the lower postocular scale in broad contact with the anterior temporal scale. *Brachyurophis incinctus* occurs on heavy clays, stony soils and rock outcrops in spinifex grasslands, shrublands and woodlands (Wilson & Swan

FIG 1. *Brachyurophis incinctus* specimen from Talaroo Station, Queensland (*in situ*). Photo by: Brendan Schembri.

FIG 2. Dorsal head view of *Brachyurophis incinctus* specimen from Talaroo Station, Queensland. Photo by: Brendan Schembri.

2013). The known distribution of this species is mostly restricted to interior Australia. Based on museum records, *B. incinctus* has been recorded near Erldunda in southern Northern Territory (NT), with records spanning north to the Barkly Tableland, NT. In QLD, records exist from Doomadgee and Cloncurry in the north, spanning southeast through western QLD to the Eulo district (Atlas of Living Australia (ALA) 2016; Queensland Wildnet 2016). Here, we present an extension of this species range by >400 km to the northeast of any previous museum records.

FIG 3. Habitat where *Brachyurophis incinctus* specimen was found in a mat of soil and leaf-litter between granite boulders on Talaroo Station, QLD. Photo by: Brendan Schembri.

OBSERVATION

At 21:02 hours on 6th April 2016, an adult *Brachyurophis incinctus* (Figs. 1 & 2) was found foraging in a mat of soil and leaf-litter between granite boulders (Fig. 3) on Talaroo Station (18°02′32″S 143°48′51″E; Fig. 4), 55.6 km west-northwest of Mount Surprise, Queensland. The habitat was shaded, sparse rocky boulders with thick mats of leaf-litter, bordering a creek in savanna woodland. The specimen had a snout vent length (SVL) of 294 mm, a TL of 326 mm and a mass of 12.64 g. The specimen's scalation was: 154 ventrals, 17 midbodies, 25 divided subcaudals and a divided anal scale. This is consistent with characters presented for *B. incinctus* (Storr 1967; Horner 1998; Wilson 2015). The snake was located during a fauna survey of Talaroo Station and was collected as a specimen for the Queensland Museum (Scientific Use Registraion Certification, Registration Number 462; J95750). The air temperature at the time of observation was 24°C, humidity was low to moderate, sky was clear and the moon was 0%. Heavy rainfall (>200 mm) occurred two weeks prior to this record and pooled water was still present in some low-lying areas.

DISCUSSION

This record extends the known distribution of *Brachyurophis incinctus* by 427 km to the northeast of the nearest observational records (20°30′10.25″S, 130°39′23.92″E; Ernest Henry Mine, Cloncurry, QLD; Queensland Wildnet, 2016) and by 527 km to the east of the of the nearest museum record (South Australian Museum, R8795, 20°55′58″S, 138°49′07″E Doomadgee, QLD). The closest museum record to the southwest of the Talaroo specimen is 543 km distance (Museum & Art Gallery of the Northern Territory, R35142: 20.717° S, 130.483°E; Mount Isa, QLD). This is the first known record

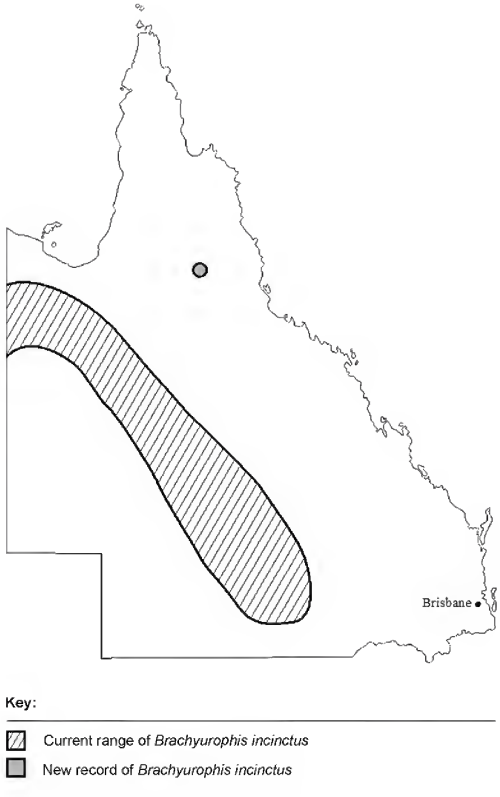

FIG 4. Queensland distribution of *Brachyurophis incinctus* (Wilson 2015) with current range extension record from Talaroo Station (18°02′32″S, 143°48′51″E), 55.6 km west-northwest of Mount Surprise, Qld.

of this species from the Einasleigh Uplands Bioregion (bioregions of Queensland defined in Queensland Government 2016), an area that is also known to support the ecologically similar congeners *Brachyurophis australis* and *B. campbelli* (Cogger 2014; Wilson 2015; ALA 2016).

It is unclear whether our record of *B. incinctus* in the Einasleigh Uplands represents an isolated population, as reported for the Spinifexbird *Eremiornis carteri* (Kutt 2003) and Northern Phasmid Gecko *Strophurus taeniatus* (Vanderduys *et al.* 2012a), or whether it lies within an unrecognised continuous distribution. The small size, semi-fossorial and nocturnal nature of *B. incinctus* combined with limited herpetological surveys of the region (Vanderduys 2016) may account for the absence of additional records from this region. There are several unconfirmed reports of this species from outside of its known range (QLD Wildnet 2016), suggesting that *B. incinctus* does in fact have a much broader distribution and warrants further investigation.

The Einasleigh Uplands and adjacent Gulf Plains Bioregions of Queensland are known to be under-represented in biological survey efforts, particularly herpetofaunal searches (Vanderduys 2016). Consequently, several new species have been described in recent years from both the Einasleigh Uplands and Gulf Plains since these regions have gained more attention from herpetologists (e.g. Oliver *et al.* 2014; Oliver & Doughty 2016; Vanderduys 2016). A number of taxa, with core ranges in the neighboring Gulf Plains and Mitchell Grass Downs regions have also been recorded in the Einasleigh Uplands in recent years (Kutt 2003; Vanderduys *et al.* 2011, 2012a, b). As these regions are heavily grazed and under pressure from numerous other threatening processes (Catling *et al.* 1999; Kutt *et al.* 2012a,b), further surveys should be seen as a priority to fill gaps in our faunal knowledge.

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IN MEMORIUM

Alan Bartholomai (1938–2015)

FIG. 1. Alan preparing a plaster jacket around an amphibian skull found at the Crater, Rewan in Central Queensland (1966).

Alan Bartholomai AM, PhD, passed away at the age of 76, on the 17 December 2015 following a short illness.

Born in Boonah, south-east Queensland on the 31 December 1938, Alan was the only son of Harold Bartholomai and Vera Evelyn Love. He attended the Boonah Rural State School, and later the Southport State School after the family moved there. He gained his Junior Certificate at Gatton College (as a boarder) and his Senior Certificate at Southport State High School. The latter's school motto, *Respice Finem* (to look to the end result), likely struck a chord with the young Alan, and in some respects symbolises his future career.

Alan's interests in geology were established early, and he wrote in his unpublished memoirs that:

"One of my teachers brought some fossil plants in to school and these really fascinated me. He asked my parents if he could take me out to where they were found and I spent an afternoon splitting shale. The thrill was seeing a plant, preserved as a gossamer thin film, exposed to the world for the first times in hundreds of millions of years. This first taste of geology was to be the stimulus when I

entered university to suggest there may be a career in something as stimulating as interpreting the past life on earth."

His parents were advised by the Board of the Canteens Trust Fund that he should pursue studies at the University of Queensland, and he secured a Commonwealth Scholarship to the Faculty of Science, reflecting his interest in Geology and Zoology.

Geologist and Palaeontologist

Alan finished his Bachelor of Science degree at the University of Queensland in 1960 and that same year was appointed Curator of Geology at the Queensland Museum by then Director George Mack. Alan was the only scientist on staff, apart from George himself. During his undergraduate training he benefitted from having the mentorship of Jack T. Woods who was a special lecturer in geology at the University and later a Director of the QM himself. Woods gave a course on vertebrate palaeontology, and his enthusiasm must have been infectious for the young Alan. Later on, after Alan had already joined the Museum, Woods taught him how to prepare line drawings and illustrations for papers. This skill is clearly in evidence in his published research papers.

Alan commenced his MSc research on fossil kangaroos under the supervision of Professor Dorothy Hill, who recommended he submit his published papers as a Master of Science in 1969. Continuing to build on this work for his doctorate, Alan's PhD on the "*Stratigraphy, skeletal morphology and evolution of the Upper Cainozoic and recent Macropodidae of Queensland*" was awarded in 1973.

From the mid-1970s onward, Alan's research focused on Cretaceous fish, though he often quipped that this was mostly because all of the more interesting groups (dinosaurs and marsupials), were already being studied by other researchers. Due to the demands of being Director of the Queensland Museum from 1969 to 1999, he published sporadically, but in his retirement he re-engaged with his research on the Cretaceous fish faunas of the Great Australian Basin and aimed to undertake a progressive review of these faunas, including the identification and description of new species. This work resulted in eleven papers establishing him as a preeminent researcher in this field and he has contributed more than any other palaeontologist in documenting this fauna. Many of the fish groups he worked on had not previously been recorded from the Southern Hemisphere, and thus his research had important implications in understanding the palaeogeography of the Cretaceous fish fauna worldwide.

Due to the fact that Australian natural science museums are each separately state funded, it was inevitable, especially at that time that most researchers tended to work in isolation. Alan was one of the few locally trained vertebrate palaeontologists employed in Australia and he continued to work largely independently for most of his research career. Nevertheless, he co-supervised a University of Queensland Masters Qualified Student, Tempe Lees who was based at the Museum, and he was also an Honorary Research Fellow of James Cook University. Joint papers were published with colleagues that included research on Cenozoic marsupials with Michael Archer and on the fossil record of turtles in Australia with Gene Gaffney. A significant career highlight included the co-announcement, with Anne Warren, of the discovery of Triassic vertebrates from Australia in the prestigious science journal *Nature*. This was followed by the description of what was then the most complete dinosaur known from Australia, *Muttaburrasaurus langdoni*, with Ralph Molnar.

Museum Director

Alan became Director of the Queensland Museum (QM) in 1969 and he oversaw the rapid expansion of the Museum from about 44 staff to approaching 200 at the time of his retirement. In the following year, on the advice of the previous Director, Jack T. Woods, Alan moved to re-establish a Board to oversee the development and enhancement of the Queensland Museum; the previous Board being dismantled in 1907.

It was apparent that the newly appointed Director and Board worked closely and cohesively to advance the Museum. This was assisted by lengthy appointments of Board members, and also by the connections of some members to Government at the highest levels. The Board also provided a degree of autonomy for the Museum as it took the museum out of the direct Departmental control of everyday decision-making. It was also fortunate that at this time the State was experiencing a period of economic growth and stability. With the new Board helping to guide the Queensland Museum in exciting new directions, combined with the State's economic prosperity, the Museum was suddenly able to expand and grow under Alan's directorship. Opportunities arose for the expansion of curatorships with positions in arachnology, anthropology, molluscs, history and technology, higher invertebrates, lower invertebrates, industrial archaeology, maritime archaeology and lower entomology being advertised and filled, as well as a scientist in charge of materials conservation. This recruitment of professional staff had started in the mid-60s but gained major momentum in the early 1970s under Alan's stewardship. The appointment of such a group of highly qualified scientists was instrumental in establishing, for the first time, a research culture that would help guide the direction of the Queensland Museum and result in significant advances in recording and understanding the State's biodiversity, palaeontological record and cultural heritage.

After taking an overseas study tour in 1974, it became clear to him that if the Queensland Museum was to build its visitation numbers, and continue to attract local and international tourists, it needed to refresh and upgrade its displays. Under the leadership of his deputy, Bruce Campbell, and with the employment of new design staff, old exhibitions were refurbished and new displays and diaromas were prepared. Alan was responsible for buying the life-sized models of *Triceratops horridus* (in 1976) and *Tyrannosaurus rex* (in 1978) that have become iconic symbols of our Museum ever since.

Expectations of the role of professional staff changed under Alan's directorship and this resulted in a group of academically trained, highly qualified, professional curators, who were able to keep pace with advances in science and/or cultural heritage and technology. He invested significant trust and independence in his professional staff and largely supported their judgement on research and collection matters, and maintained a highly effective working relationship with his Deputy Director, Bruce Campbell. Through strategic appointments, researchers like Michael Archer, Lester Cannon, Jeanette Covacevich, Peter Davie, Valerie Davies, Glen Ingram, Patricia Mather, Michael Quinnell, Robert Raven, Mary Wade, Carden Wallace and others were able to help document and lay the foundations for understanding the State's biodiversity. Many of these appointments were to go on to establish major international reputations and bring great respect and repute to the Museum. In later years new opportunities led the Museum to undertake responsibility for Queensland maritime archaeology and developed a specialist conservation unit to support this research. Alan was a strong supporter of the museum scientific journal, the *Memoirs of the Queensland Museum*, and a second journal on cultural heritage. These publications provided an important venue for publishing research relevant to the State's biodiversity and cultural heritage. Throughout his tenure and especially in the 1970s he had a good record for employing female professional staff, not something universal in museums around Australia nor in government departments at that time. He also encouraged participation of staff in museum and professional organisations and collaborative research projects. All these things are accepted practice now, but in a state-based organisation they were once novel. Two of his curators at his farewell morning tea complemented Alan on establishing a collegiate structure in a public service organisation. They likened his role as both a conductor and impresario who guided the Museum through its most significant period of change and growth.

FIG. 2. The Honourable Premier of Queensland, Sir Joh Bjelke-Petersen KCMG at the opening of the Queensland Museum at South Bank, 1986 being met by Alan and Patricia Bartholomai with Connal Gill (Chairman of the Board of Trustees of the Queensland Museum), and his wife Betty.

By the 1970s, the Exhibition Building at Fortitude Valley, the home for the Museum since 1899, had become completely inadequate to house a contemporary museum. Despite its grandiose appearance, the basic unsuitability of the building was exacerbated by the major increase in staff, the quickly growing collections, the lack of air-conditioning, largely unsuitable and inadequate storage conditions, rainwater leaks, aging infrastructure, termite infestations and significant structural problems! These limitations and challenges collectively served to highlight the inadequacies of the Exhibition Building, as a permanent home for the collections. The Board of the Queensland Museum recognised on its first meeting, on 24 September 1970, that a new home for the collections was the immediate priority.

In 1985, the 'Old Museum' was closed to the public, and the following year the 'new museum' was opened with much fanfare as part of the new South Bank Cultural Centre Precinct. This relocation required the movement of staff, development of new exhibitions and transfer of the entire museum collection. Alan early-on had recognised that the success of the redevelopment would be judged, in part, by the quality of the new exhibitions. To ensure the best outcome, he appointed a consultant, Dame Margaret Weston, Director of the Science Museum, London as an Advisor to the Queensland Museum Board during the planning and establishment of the new museum. This ambitious display program was overseen by Bruce Campbell. The intensive period of design, production and installation commenced in 1980 and took six years to

complete, resulting in 5000 square metres of exhibitions, including 15 thematic exhibitions and a 'dinosaur garden'. The reconstruction of *Muttaburrasaurus*, the most complete dinosaur known from Australia, occupied pride-of-place on the new main display floor. It was the first Australian dinosaur to be displayed as a mounted, fully-articulated skeleton, and was partly funded from an Australia-wide *Kellogg's Rice Bubbles* pack promotion. The relocation of collections from the Exhibition Building to the Cultural Centre was the largest and most complex collection move for any Australian museum, up to that time. The detailed planning also resulted in a restructuring of the Museum's organisation, and development of a cohesive program of public programs and outreach activities.

Alan became Director only one year after Sir 'Joh' Bjelke-Petersen became Premier of Queensland in 1968, as leader of the Country/Liberal Party Coalition (later National Party). This conservative government lasted until 1989, and while it heralded a period of considerable economic development within Queensland, it became mired in controversy in its final years. With the incoming Labour Goss government in 1989, the same skills and political astuteness that had served Alan so well under the previous regime now had to accommodate a significant change of direction, restructuring, and a new culture that swept through the Queensland Public Service. The new Labour government was to lead a major conservation agenda, and the Museum was quickly able to establish an important role in providing advice and faunal information vital to the new state-wide environmental management initiatives.

Alan always maintained strong lines of communication with government, but as someone who had had such a long senior role under conservative rule, it is a testament to Alan that he was seen by the incoming Government as somebody they could work with, especially at a time when many members of the previous administration were being 'purged'. Nevertheless, the inevitable changes to the culture of the Public Service, and its increasing levels of corporatisation, had significant impacts on the operation and running of the Museum. There were now significantly higher levels of scrutiny, new levels of accountability, and generally increased expectations for the organisation and its management. Alan would have viewed some of these changes with concern.

On his retirement, the Board of the Queensland Museum honoured Alan with the title of Emeritus Director, acknowledging his leadership and his contributions to the museum.

Ensuring greater community access to the collections of the Queensland Museum

At the same time as the relocation and redevelopment of the Queensland Museum in Brisbane was occurring, Alan began an ambitious program to extend the reach of the Museum, across the State, by establishing a series of regional branches. Through these branches it was intended that the wider Queensland regional public would have greater access to collections, displays and the QM's unique expertise. Alan also acknowledged the expertise and interests of regional communities so along with each development came strong community commitment through the appointment of local advisory committees.

In 1982 the first official branch, the Museum of Lands, Mapping and Surveying, opened in Woolloongabba. Two years later, in 1984, *Woodworks* opened at Gympie, being a joint development with the Department of Forestry. *Woodworks* focussed on the history of Queensland's forestry and timber industry. Subsequently Alan played a key role in the development of the *Cobb and Co Museum* in Toowoomba, the *Museum of Tropical Queensland* in Townsville, and the *Science Centre* in Brisbane.

The *Cobb and Co Museum* opened in 1987, to initially hold a large collection of horse-drawn vehicles previously donated to the museum by W.R.F. (Bill) Bolton. A planned 'Printing Museum' at the old Queensland Government Printing Office in George Street, did not go forward, but in the same building, in 1989, was established an interactive *Science Centre* that was to prove hugely popular.

FIG. 3. Alan Bartholomai looking at the fibreglass replica of Lark Quarry as Dr Mary Wade and Howard Plowman remove the latex layer revealing the footprints of small dinosaurs.

The Queensland Museum North Queensland Branch was established in 1987, and planning for what would become the *Museum of Tropical Queensland*, commenced in 1990. In 1990 the Pandora Foundation was established in Townsville to fund research on the wreck of the famous shipwreck Pandora. Alan oversaw the plans for a new building, and the supporting infrastructure and resources to support the activities of the new Museum which opened shortly after his retirement in 2000.

A *Museum of North West Queensland* opened at Mount Isa, a joint initiative with the Mount Isa City Council, and a manager was appointed in 1995 to oversee its development. The planning for the Ipswich *Workshops Railways Museum* also occurred at this time. Another long planned technology museum in Coomera did not eventuate and the museum's involvement in some of these initiatives lapsed due to budgetary constraints, and other factors in the subsequent decade. Even allowing for this attrition, the Queensland Museum was then, and remains, one of the most decentralised museums in the world, with an enormous community reach.

During this same period the QM loans, part of the Education Section, provided the opportunity for greater access to collections through the development of a State-wide loans service. This program was enhanced in the mid-1980s by Education Officer, Rae Sheridan, and currently has the largest reach of any museum loan service in the world.

A larger role

Alan's influence extended beyond his nominal role, and he was a valued member of a large number of State and National committees. In particular, Federally he was a member of the Interim Council of the Australian Biological Resources Study, Board of the CRC for Tropical

Rainforest Ecology, and Deputy Chairman of the Advisory Committee for the *Taxation Incentives for the Arts Scheme*, and also for the Advisory Committee on *Illegal movement of Cultural Property*. He was also a member of the Committee for establishing the National Maritime Museum of Australia.

At the State level he was, amongst others, a Member of the Aboriginal Heritage Committee, Ipswich Rail Technology Centre Advisory Committee, John Oxley Library Committee, Queensland Hall of Science Industry and Health Development Committee. He was also a continuing member of the World Wildlife Fund for Nature, a Member of the Brisbane RAAF Club, a member of the Lizard Island Research Committee (Australian Museum), and a Past-President and member of the Royal Society of Queensland.

Significant Acquisitions and Collections

As a geologist and palaeontologist, Alan did much work collecting fossil vertebrate material from sites around south-east Queensland, particularly the Darling Downs, which strongly reflected his research interests at that time. He did venture further afield, and was fortunate to join expeditions with the American Museum of Natural History to Western Queensland in 1971. Alan also joined Dr Alex Ritchie (Australian Museum) and Dr Anne Warren (later at the La Trobe University) to undertake some of the first palaeontological field work at the Rewan site in Central Queensland, which has yielded some of the most important Triassic fossils known from Australia. In 1978 he also joined the British Museum (Natural History) expedition to collect Queensland Mesozoic vertebrates.

One of the sites Alan discovered would significantly revolutionise our understanding of marsupial evolution in Australia. Dr Michael Archer recounts that in 1975 (three years after he arrived at the Queensland Museum):

"Alan was rattling off tales about his paleo experiences around the tea table and mentioned that he'd visited Riversleigh and seen a new diprotodontid jaw".

FIG. 4. Alan Bartholomai at Riversleigh in 1965.

Archer goes on to write that:

"When I asked him where it is, he looked at me like I was demented. 'Still there of course--that limestone's harder than cement!' ".

This casual comment would lead to over 40 years of field work and research on the Riversleigh fossil sites in north-western Queensland by Drs Archer, Sue Hand and Henk Godthelp and teams of researchers and volunteers, all undaunted by the 'cement-like' hardness of the limestone.

Some of the most important discoveries in Australian palaeontology were facilitated by members of the public. In 1963, a Queensland Grazier, Doug Langdon, discovered the skeleton of a dinosaur near the township of Muttaburra. It was collected by Alan and Queensland Museum entomologist Ted Dahms, and after many years of preparation was finally described in 1981 by Alan and Ralph Molnar as *Muttaburrasaurus langdoni* to honour its local discoverer. The specimen of another dinosaur, *Minmi*, was also

FIG. 5. Doug and Pearl Langdon and Alan at the 50th anniversary of the discovery of *Muttaburrasaurus langdoni*. The photograph was taken in 2013 at the Lost Creatures exhibition, Queensland Museum and Science Centre. The reconstruction of *Muttaburrasaurus* occupies a central position in this display.

collected by Alan from near Roma in South West Queensland, the bones being brought to his attention by a member of the public.

Reflecting his broad knowledge and interests, Alan also exercised lasting influence on the development of the Museum's cultural history collections. In 1975, for example, he brought back from the United States an important collection of personal memorabilia relating to Sir Charles Kingsford Smith, one of Queensland's favourite sons, and a world renowned aviation pioneer.

International Collaboration

Despite being a museum with a primarily Queensland state focus, Alan nevertheless had a broader international vision. He recognised the new opportunities for cultural tourism with Asian trading partners and also the interest in Australia's unique fauna in Asia. Building on the sister state relationship between Queensland and the Prefecture of Saitama, Japan, and to celebrate the 5th Anniversary of that agreement, the Saitama Prefectural Museum entered into an agreement to exchange collections with the Queensland Museum in 1989. Through exhibition exchanges with international museums he maintained a forward-looking focus for the museum.

Alan was also part of the Australian Delegation to attend the 1998 United Nations Environment Program *Convention on Biological Diversity* (CBD). Here they presented the 'Darwin Declaration' which was the result of a workshop to discuss 'Removing the Taxonomic Impediment' held in Darwin earlier that year. The Darwin Declaration was the first meeting of a group of technical experts to address the implementation of the Global Taxonomy Initiative, and was an important milestone in this process. The declaration stressed the importance of biological collections for taxonomy, and also the need to mobilise the data contained in such museum collections for research, policy purposes and environmental management. It also highlighted the ongoing need for further research to document the biodiversity of Australia, and its largely unique flora and fauna.

Repatriation of the Sir William Macgregor Collection of Papua New Guinean Artefacts

Perhaps some of the most effective international links were developed with the newly independent Papua New Guinea. In the 1970s the approaching independence of Papua New Guinea, and particularly the establishment of a new National Museum, resulted in pressure for the return of the Macgregor Ethnographic Collection (Quinnell 2000). Sir William Macgregor had been the Administrator and later Lieutenant-Governor of British New Guinea between 1888 and 1898, during which time he made extensive collections of indigenous artefacts which were given to the Queensland Museum after he became Governor of Queensland in 1909. Alan sought legal advice, and with the support of the Board, offered to return part of the collection. Thus, between 1979 and 1999 Michael Quinnell, Senior Curator, Torres Strait Islander and Pacific Indigenous Studies, oversaw the return of 3297 items, one of the largest international repatriations of ethnographic collections ever undertaken from Australia, and indeed by any museum in the world. The good will that was

generated between the Papua New Guinea National Museum and the Queensland Museum resulted in both Boards of Trustees agreeing in February 1980 that a significant part of the Macgregor collection be allowed to remain in Queensland.

Honours

Awarded a Member (AM) of the Order of Australia in the General Division 'For service to the advancement of science, particularly through administrative roles with the Queensland Museum.'

Alan as a man

Alan was fortunate to be appointed Director at a time when the Queensland economy was booming. He had the ability to talk and interact with people at all levels, no doubt assisted by his ability to tell great stories, which were often amusing and then further embellished in their telling.

The photograph of Alan in the mud (Fig. 6) was taken during a 6 week, Queensland Museum/ American Museum of Natural History joint expedition in 1971 at 'Davenport Downs' in Western Queensland. According to his unpublished memoirs the party had dropped him off at the station while they proceeded on to the Strzelecki Track, and Adelaide. Alan writes:

"As the party departed, a bank of black cloud appeared and down came the rain. It rained and rained for days and I was completely cut off. When flight details were finally confirmed by radio, Trans Australian Airways informed us they wouldn't stop at 'Davenport Downs' because of the conditions. They would only pick me up from the airstrip at 'Diamantina Lakes' some 50 kms to the north requiring us to traverse numerous boggy and flooded gullies. Luckily the manager was agreeable to transporting me there, although the trip was a nightmare and we arrived just before the plane, having dug ourselves out of many bogs. I was covered in mud and had grown a beard during the field trip so I must have looked like the greatest hobo. The plane refused to stop in case it bogged down and I had to run for it, tossing in my swag and being pulled aboard by the flight attendant." It was a different time.

FIG. 6 Photo of Alan at 'Davenport Downs' with captions by Pat Rich, one of the researchers on the field trip.

An everyman, he was comfortable in his role and in his achievements. He was also sagacious, with an ability to discern and discriminate in his dealings with government, benefactors and the general public. Ebullient, socially gregarious and self-deprecating, his wonderful sense of humour was utterly contagious.

A stoic man, he faced the opening of the new Museum in October 1986 just three months after his oldest daughter had been tragically killed in a car accident, and in 1989 he returned to work two weeks after quadruple heart bypass surgery. His dedication to the institution was acknowledged through his being awarded a Queensland Museum Medal and then later an AM for his outstanding contribution of over 40 years of service to the Museum.

He was also a private man, who cherished his family and his home life. He wrote in his memoirs:

"My life has been a mixed one, ranging from extreme highs to extreme lows. The love, stability and support of family have ensured that the former outweigh the latter. Of all my achievements, I count my relationship with my family by far and away the top of them all. What more can anyone ask of life?"

During his tenure, the Queensland Museum underwent the most significant transformation and metamorphosis in its history, and Alan, with the major support of the QM Board and an excellent and highly committed group of professional staff and volunteers, oversaw this transformation into the Museum that we largely know today. Museums can be perceived as closed places that are inaccessible, strange, even intimidating – Alan helped open the doors to make the Queensland Museum, at a whole range of levels, into a more open and accessible institution for all Queenslanders.

NAMES CREATED TO HONOUR ALAN BARTHOLOMAI

Didymalgia bartholomai Cook, 1997 (Fossil Gastropod)

Megateg bartholomai Raven & Stumkat, 2005 (Spider)

Hypsiprymnodon bartholomaii Flannery & Archer, 1987 (Fossil Marsupial)

LIST OF FOSSIL TAXA DESCRIBED BY ALAN BARTHOLOMAI

Marsupials

Thylacoleo crassidentatus Bartholamai, 1962
Sthenurus antiquus Bartholomai, 1963
Sthenurus notabilis Bartholomai, 1963
Troposodon Bartholomai, 1967
Protemnodon chinchillaensis Bartholomai, 1973
Protemnodon devisi Bartholomai, 1973
Fissuridon pearsoni Bartholomai, 1973
Macropus rama Bartholomai, 1975
Macropus woodsi Bartholomai, 1975
Macropus piltonensis Bartholomai, 1975
Troposodon Bartholomai, 1978
Troposodon bluffensis Bartholomai, 1978
Protemnodon snewini Bartholomai, 1978
Macropus (Osphranter) pavana Bartholomai, 1978
Phascolarctos stirtoni Bartholomai, 1968
Dasyurus dunmalli Bartholomai, 1971

Reptiles

Kadimakara Bartholamai, 1979
Kadimakara australiensis Bartholamai, 1979
Kudnu Bartholomai, 1979
Kudnu mackinlayi Bartholomai, 1979

Dinosaur

Muttaburrasaurus Bartholomai & Molnar, 1981
Muttaburrasaurus langdoni Bartholomai & Molnar, 1981

Fishes

Cooyoo australis Lees & Bartholomai, 1987
Richmondichthys Bartholomai, 2004
Ptykoptychion wadeae Bartholomai, 2008
Euroka Bartholomai, 2010
Euroka dunravenensis Bartholomai, 2010
Eurokidae Bartholomai, 2010
Pachyrhizodus grawi Bartholomai, 2012
Marathonichthys Bartholomai, 2013
Marathonichthys coyleorum Bartholomai, 2013
Stewartichthys Bartholomai, 2013
Stewartichthys leichhardti Bartholomai, 2013
Canaryichthys Bartholomai, 2015
Canaryichthys rozefeldsi Bartholomai, 2015

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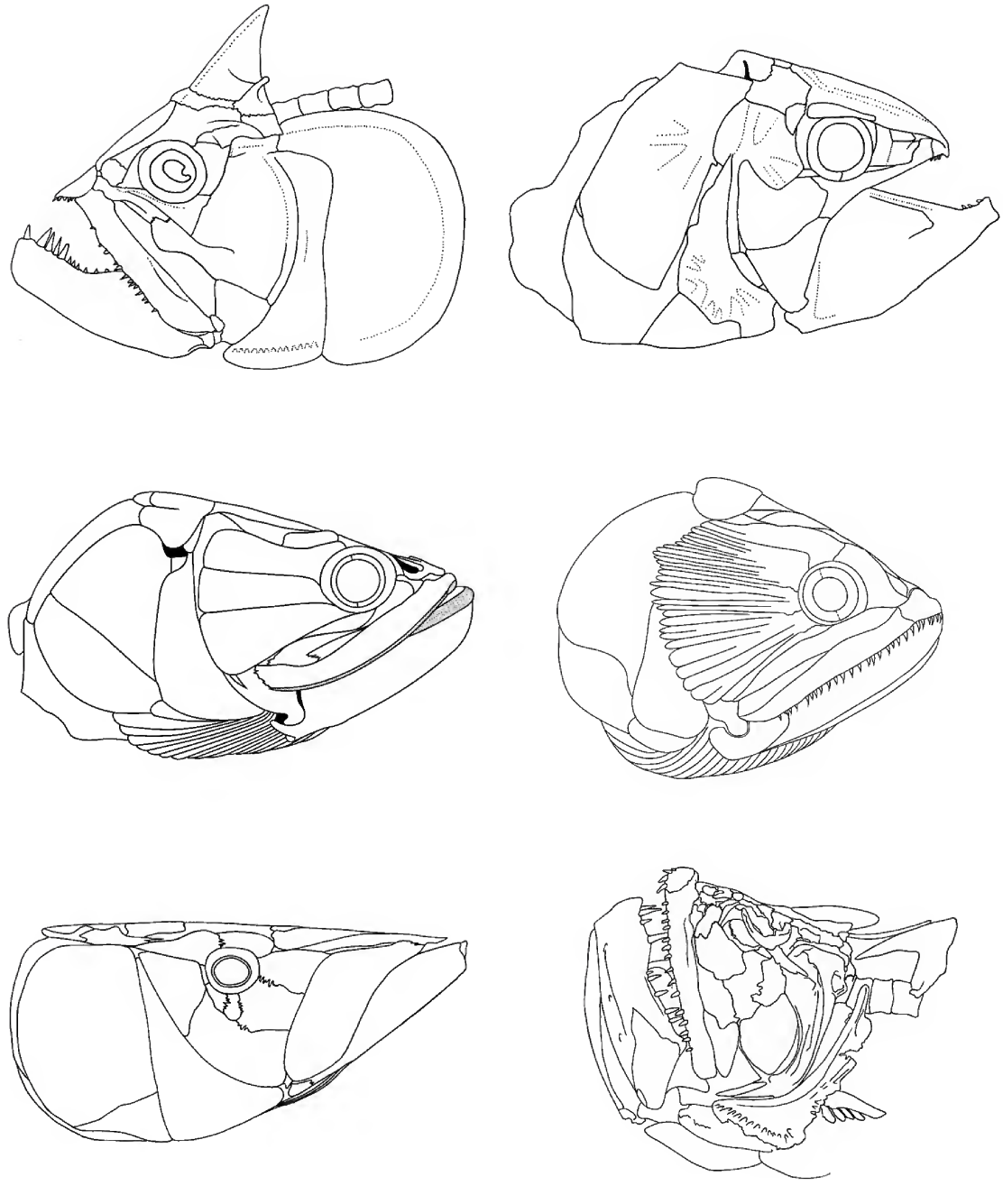

FIG. 7. Alan published eleven papers on the Cretaceous fish of Queensland, with much of this work done in his retirement. His research reviewed and updated existing studies and helped lay the foundations for an understanding of the diversity of fish species in the fauna, and he was working on the descriptions of new species at the time of his death.

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A Queensland Government Project
Typeset at the Queensland Museum

Sex-ratio bias in *Laevistrombus canarium* Linné, 1758 (Gastropoda: Strombidae) from Far North Queensland, Australia

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ABSTRACT

In general, sex-ratios in herbivorous gastropods show a strong female bias, particularly in the family Strombidae of the Indo-Pacific. Previous studies of Indo-Pacific strombs point to an underlying female bias in most species. However, the full spatial extent and potential mechanisms driving this phenomenon are currently unknown. Therefore, we studied two populations of *Laevistrombus canarium* Linné, 1758 over a four year period to explore sex-ratio bias and to investigate the underlying mechanisms. Furthermore, the current study investigated methods to test for sex-ratio bias in strombs where samples are limited and sampling is problematic We sampled individuals from two reefs in Far North Queensland, Australia, with different benthic compositions, despite their close proximity (approximately 4 km apart). In agreement with previous studies, we also found a strong bias towards females. This bias remained consistent across both locations and changes in benthic substrate. Our findings are consistent with models suggesting inherent genetic factors regulate natural patterns of sex imbalance in these strombs. These findings also suggest that there are as yet unidentified stromb life-history characteristics associated with the origin and maintenance of this phenomenon. ❐ *Life history, Phylogenetic constraints, Sampling effort, Sex imbalance*

A significant sex imbalance favouring females occurs in many gastropod populations (Abbott 1949; Griffith & Castagna 1962; Wiedemeyer 1998; Mutlu 2004). This is particularly common in the Strombidae, where a consistent ratio of at least three males to four females has been observed in many taxa (Abbott 1949; Wiedemeyer 1998; Mutlu 2004; Cob *et al.* 2009). Despite this phenomenon being regularly documented, the mechanisms underlying it are currently unknown.

Sex imbalance in some populations of gastropods is highly spatially or temporally variable. For example, in populations of *Strombus pugilis* Linné, 1758, although monthly counts have shown a significant bias towards females throughout most of the year, anomalous counts have also occurred where males were more numerous than females (Cardenas *et al.* 2005). Historically, this variability has been attributed to low population densities combined with the natural clustering behaviour of these taxa. This is because sparsely distributed individuals that

randomly encounter each other preferentially form small clusters in which sex-ratios can be artificially skewed as a sampling artefact (Catterall and Poiner 1983). Previous studies in which sex-ratio biases have been observed may also be subject to this sampling phenomenon, as these studies have often only sampled small numbers of individuals from a single cluster because of either sampling constraints, or because sex-ratios have not been the focus of the original data collection.

Sex-ratios in some stromb taxa may also be impacted by anthropogenic processes (Randall 1964). For example, populations of the large Caribbean *Lobatus* Swainson, 1837 tend to have a more balanced sex-ratio than those observed in Indo-Pacific strombs (Abbott 1949; Griffith & Castagna 1962; Wiedemeyer 1998; Stoner & Ray-Culp 2000; Mutlu 2004). It is suggested that fishing could be affecting the natural sex balance within these populations, because commercial fisherman in the Caribbean are known to select for large female *Lobatus gigas* Linné, 1758, leading to a male biased sex-ratio through overharvesting of females (Randall 1964). However, the full impact of fishing is questionable, as unfished populations of *L. gigas* are also known to show no sex-ratio bias (Randall 1964; Stoner & Ray-Culp 2000).

Given these disparate findings it is important that appropriately robust sampling be conducted across both space and time to fully understand sex-ratio variability within Strombidae. There has been one study specifically into stromb sex-ratio on *Laevistrombus turturella* Röding, 1798 (incorrectly identified as *L. carnarium* Linné, 1758) where a long-term sex bias towards females was found with an average of 1/1.88 ± 0.16 males to females (Cob *et al.* 2009). However, it is unclear from the literature whether other previous surveys publishing sex-ratio data have been undertaken using multiple samples or robust sampling procedures, making the drawing of conclusions on the generality of this phenomenon problematic.

Stromb mating aggregations occur seasonally and are consistently larger than clusters observed at other times of year (pers. obs.). Therefore, they are one type of aggregation that may be less susceptible to the problem of sampling bias, assuming that there is no inherent sex-ratio bias in these aggregations due to mating-system characteristics. Thus, sampling mating clusters offers a potential cost and time effective method to establish the actual sex-ratio for a given limited sized populations at a specific location, or when only limited sampling is possible.

The current pilot study investigated methods to test the sex-ratio bias in strombs where samples are limited and sampling is problematic. In particular populations of the Indo-Pacific stromb *Laevistrombus canarium* were studied over three years at two different sampling locations with different benthic substrates. Both populations were not subject to fishing or commercial collecting. We aimed to establish the level and pattern of sampling required to accurately determine sex-ratios in these two *L. canarium* populations and to determine whether a consistent sexual imbalance of approximately three males to four females occurred. We also aimed to determine whether sampling large mating aggregations at a single point in time would accurately reflect population sex-ratios obtained from longer-term sampling of smaller non-breeding clusters over multiple years, thus providing a cost- and time-effective method of studying this phenomenon in the future.

MATERIALS AND METHODS

Field sampling involved nine collecting trips at low tide to two coastal reefs adjacent to Port Douglas, Queensland, Australia between June 2013 and May 2016. Collecting in coastal northern Queensland is problematic for three reasons: 1) the prevalence of estuarine crocodiles, 2) the inability to dredge for samples due to substrate, and 3) the limited number of tides that expose and enable access to the colonies.

We conducted six collecting trips to Alexandra Reef (16.53 S, 145.49 E) and three to Four Mile Beach (16.51 S, 145.47 E). Two non-mating cluster samples were obtained from Four Mile Beach and three from Alexandra Reef over the full study period (total n = 5). One mating cluster sample was obtained from

each location in June/July 2013 (total n = 2) and an additional two mating cluster samples were obtained from Alexandra Reef over the full study period. These two localities have different benthic compositions despite their close proximity (approximately 4 km apart). It is unlikely that adults regularly move between the two sampling locations due to unfavourable intervening habitat and living specimens are rarely observed in the interspace between the two populations (pers. obs.). However, due to a lack of data on patterns of larval dispersal, it is possible that juveniles could recruit to both locations from a single larval source population (Delgado *et al.* 2006; Paris *et al.* 2006; Aldana-Aranda & Perez-Perez 2007).

On all sampling occasions, once an individual *L. canarium* was located, the nature of the benthic substrate (e.g. sandy vs. silty) was noted and one metre wide transects were walked from the high-tide mark to the waters-edge covering the extent of the area exposed by the low tide. Adult strombs were sexed on site by the absence, or presence, of a verge seen as the animal righted post-release (Abbott 1960; Cob *et al.* 2008). Mating and non-mating clusters were identified by the presence or absence of copulation activity.

The first analysis used each non-mating cluster sample at each time/site as a replicate and combined the data from both sites. This pooling was necessary to obtain a sufficiently robust sample of non-breeding clusters over the three year period to accurately establish a measure of the background sex-ratio in the Port Douglas region. The median sex-ratio obtained from this pooled data set (n = 5) was then compared to that expected in a sex balanced population (1 male : 1 female) using a Wilcoxon One-sample Signed rank test.

Next, an independent samples Kolmogorov-Smirnov test was used to test for differences between the median sex-ratios obtained using the larger mating cluster samples as replicates, as compared to the smaller non-mating cluster samples.

Data from the Alexandra Reef site, which had the largest number of non-mating cluster samples, was then used to test if the numbers of males and females observed in individual mating clusters differed significantly from the ratio obtained by combining all non-mating cluster samples at this same location using a chi-squared analysis.

RESULTS

The sex-ratio in these two populations of strombs was variable in both space and time (Table 1). However, analysis of the non-mating clusters pooled across sites showed a consistent imbalance in sex-ratio in favour of females (1 : 1.8), which differed significantly from an expected balanced (1:1) sex-ratio ($W_{5,1}$ = -2.060, p < 0.039,

TABLE 1. Sex-ratios of two populations of *Laevistrombus canarium* (n = 9) from North Queensland, Australia
*Designates a mating cluster

Locality	Date	Sex		Sex Ratio (M:F)	Substrate
		Male (n)	Female (n)		
Four Mile Beach*	07/2013	19	22	0.86	Rubble sandy mud
Four Mile Beach	09/2013	3	5	0.6	Rubble sandy mud
Four Mile Beach	07/2014	3	6	0.5	Sandy mud
Alexandra Reef*	06/2013	8	17	0.47	Rubble and sand
Alexandra Reef	09/2013	6	12	0.5	Rubble and sand
Alexandra Reef*	07/2014	15	31	0.48	Weed and sand
Alexandra Reef	07/2014	8	11	0.73	Weed and sand
Alexandra Reef*	08/2015	15	38	0.39	Sand
Alexandra Reef	05/2016	14	28	0.5	Rubble, weed & sand

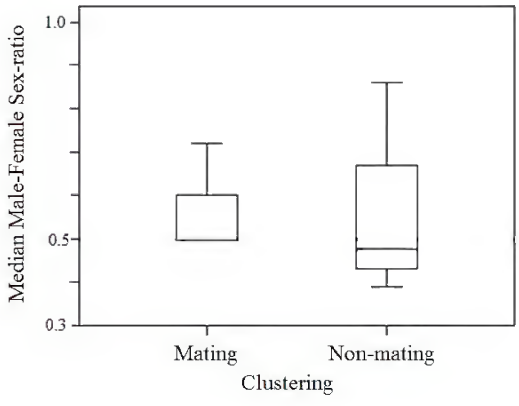

FIG. 1. Box plot of the median ratio of males to females for the populations of *Laevistrombus canarium* showing the mating and non-mating cluster samples from Alexandra Reef, North Queensland, Australia.

figure 1). The median sex-ratio derived from the mating cluster samples also showed an imbalance favouring females (1 : 1.9) that did not differ significantly from the ratio obtained using non-mating clusters ($Ks_{4,5}$= 0.225, p = 0.164).

At Alexandra Reef no statistical difference was observed in the proportions of males and females observed in each individual mating cluster sample and the overall proportions of each sex observed when all of the non-mating cluster samples at this site are combined ($\chi 2 = 8$, df = 6, p = 0.2381). This suggests that each of the larger individual mating cluster samples provides a relatively accurate estimate of the overall female sex bias within the population, and that this sex bias has remained relatively consistent at ~ 0.5 at this site over the three-year sampling period.

DISCUSSION

This study confirmed the presence of a significant sex imbalance favouring females in *Laevistrombus canarium* populations from the Far North Queensland coast, and the existence of a significant sex-bias towards females across the *Laevistrombus* complex (Cob *et al.* 2009). Importantly, the results demonstrate that the limited number of individuals that can be obtained during any single non-mating cluster sample are able to test hypotheses concerning the existence of a sex-ratio bias but are insufficient to quantify that bias. This has implications for planning further studies given the logistical difficulties and time constraints involved in obtaining sufficient non-mating cluster samples. Alternatively, our results demonstrate that a single sample of a large mating cluster provides data representative of the sex-ratios observed from non-mating samples pooled over longer time periods and across different sampling locations. Consequently, mating cluster samples can be used as a time- and cost-effective method of determining actual population sex ratios over much shorter time periods than would otherwise be required.

Based on mating cluster samples, the sex-ratio bias in *Laevistrombus canarium* populations was consistent across both space and time. This suggests that the general phenomenon of sex-ratio bias we observed is not simply a sampling artefact associated with sampling small clusters of individuals at single points in time. In addition, the sexual imbalance in *L. canarium* populations remained similar at each location despite different benthic substrates, suggesting that substrate conditions are unlikely to be significantly affecting sex-ratios.

One explanation for the observed sex biases found in this study could be that there is differential survival of each sex during the larval and/or immediate post-settlement period. Stromb mortality is highest during the larval dispersal stage and the period soon after settlement, with predation at this time being capable of eliminating entire breeding cohorts (Stoner *et al.* 1998). However, despite documented high mortality during these early developmental periods, evidence for differential sex-specific survival that could account for a consistent sex imbalance is lacking (Cob *et al.* 2009, 2009a). Further, because this phenomenon has been little studied, there is no evidence to support sex-ratio imbalance as a consequence of non-random recruitment of either sex to specific locations.

The consistent female sex-bias found in *L. canarium* populations from Far Northern Queensland is most likely a consequence of genetic regulation of this phenomenon both in *L. canarium* and throughout the Strombidae, as proposed by Yusa (2007). There is at least two alternatives to the XY sex-determination mechanisms found in the Caeneogastropoda, ZW-ZZ and XX-XY. Given that matings between WX females and XY males produces only one quarter male offspring, this may account for the sex-imbalance (Thiriot-Quievreux 2003, Bull in Yusa 2007). However, the sex-chromosomal arrangement found in strombids is unknown, and the presence of such constraints in this species is still conjecture, based primarily on a lack of support for alternative hypotheses.

Despite the preliminary nature of our study and limited samples sizes, our results confirm that the sexual imbalance observed in different locations reflects real sex-ratio biases found in larger more accessible populations (Cob *et al.* 2009). Therefore, investigating the evolutionary processes responsible for the origin and maintenance of such a trait, provide an exciting avenue for future research.

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Elizabeth Coxen: pioneer naturalist and the Queensland Museum's first woman curator

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ABSTRACT

Elizabeth Coxen (1825–1906) was a remarkable woman of her time. The wife of naturalist, politician and public servant Charles Coxen (1809–1876), best known as founder of the Queensland Museum, Elizabeth shared her husband's extensive scientific interests. Not only a devoted and knowledgeable companion, she achieved notability in her own right: as a conchologist, meteorologist and horticulturist. More remarkably, in 1877, in middle age, she effectively became the Queensland Museum's first woman curator (molluscs) and the first person to be paid to oversee any part of the museum's invertebrate collections. Probably she was the first woman curator of any natural history museum in Australia. Widely respected within the local scientific community, in 1886 she became the first woman to be elected as a member of a scientific organisation in Queensland. This paper documents Elizabeth Coxen's life, which has not been investigated in detail before, and records her various contributions to science and public life in nineteenth-century Queensland. Special focus is placed on her contribution to the establishment, recording and growth of the original molluscan collection of the Queensland Museum and her links with the research world of molluscs both within Australia and overseas. ❐ *Elizabeth Coxen, Queensland Museum, curators, molluscs, Charles Coxen.*

This paper has its origins in a talk presented on 13 March 2004 as part of a seminar on 'Founders of the Queensland Museum and the women who shared their vision', focusing on the careers of Charles and Elizabeth Coxen (Fig. 1A, B) and Heber and Irene Longman. The seminar was the last of the museum's annual offerings held from 1995 to mark International Women's Day. In preparing the talk it became evident how little was known about Elizabeth Coxen and how her achievements have been overshadowed by those of her husband. Charles Coxen has an entry in the Australian Dictionary of Biography (Chisholm 1969) and his life and contribution to the Queensland Museum are well recorded in the museum's official history (Mather 1986). Elizabeth Coxen, by contrast, like so many women of her era, has a lesser place in history and is sometimes confused with her sister-in-law of the same name, some twenty years her elder, who in 1829 married the famous British ornithologist John Gould and, until her untimely death in 1841, collaborated in his publications. Elizabeth Coxen, the subject of this paper, was one of 34 women featured in a previous Queensland Museum publication and exhibition, Brilliant Careers: Women Collectors and Illustrators in Queensland (McKay 1997).

However, that project predated the digitisation and online availability of critical historical data, most notably contemporary newspapers, and therefore was based on only limited information. The present paper draws on these newfound riches as well as a range of other sources, including records of the Queensland Museum (archival letters and newly-digitised registers), the Royal Society of Queensland, the Acclimatisation Society, the National Association and the Anglican Diocese of Brisbane.

Biography

Elizabeth Coxen was born Elizabeth Frances Isaac in Marshfield, Gloucestershire, England, in 1825, the eldest daughter of George Frederick Isaac, solicitor, and his wife Elizabeth, née Fromow. Coxen family papers record that the Isaacs were related to wealthy bankers; they were certainly gentry and, unlike their future in-law Charles Coxen, managed to recover from financial downturns. In 1839, at the age of 13, Elizabeth emigrated with her family to Sydney. Her father, who had practised in Pall Mall, London before his departure, set up as a solicitor in Sydney until he became insolvent in 1843. Meanwhile Elizabeth's elder brothers, Henry Edward and Frederick Neville Isaac, went north to try their luck as squatters on the rich grasslands of the Darling Downs, which had only recently been discovered by Allan Cunningham. In 1841, together with their friend Henry Hughes, they took up Gowrie station near the future city of Toowoomba, becoming some of the district's first white settlers. Henry Isaac, while retaining his interest in Gowrie, spent much of his time in Brisbane soon after the former penal settlement was opened to free settlers in 1839; in 1844 he moved into a house in Kangaroo Point built by pioneer settler Andrew Petrie (Stewart 2004). A few years later Elizabeth was also living at Kangaroo Point, probably in Henry's house, for it was from there that she witnessed Brisbane's flood of March 1847 which covered Stanley Street (Coxen 1894a).

By 1847 Elizabeth had already met her future husband Charles Coxen; she recalled that he came to town with cattle during the flood. Also about this time she lived with her brother Frederick at Gowrie and possibly this experience sparked her interest in natural history. Frederick, a skilled bushman and also interested in natural history, accompanied the explorer Leichhardt on some of his travels in the area, and, like Coxen, became an early member of the Queensland Philosophical Society, the colony's first scientific organisation. The Isaacs found many fossils in the vicinity of Gowrie, including a complete skeleton of the giant marsupial diprotodon (*Diprotodon optatum* Owen, 1838), discovered soon after they settled (Stewart 2004). At Gowrie, Elizabeth would have come into further contact with Coxen, who held several runs in the Darling Downs and Maranoa districts, including, until 1845, Jondaryan adjoining Gowrie's western boundary. By 1851, Coxen was based at Bimbian, which adjoined Dulacca then held by the Isaacs. Being a neighbouring gentleman-squatter and sharing similar interests, he would have had much in common with the Isaacs.

On 27 December 1851, at the age of 26, Elizabeth married Charles Coxen at St Ann's Church of England, Ryde, Sydney. In the following months Coxen took her back to Bimbian, then regarded as 'the boundaries of civilisation', being 'the furthermost station on the Darling Downs' (Leavitt 1887); situated on Dogwood Creek, it was on the edge of the Maranoa. Soon after the marriage other members of the Isaac family came to Queensland (until Separation in 1859 known as the Moreton Bay District of NSW). By 1854, another of Elizabeth's brothers, Frederick Edward Isaac, was living in the Parish of Bulimba, Brisbane (more extensive than the present suburb) and taking up runs in the Leichhardt district, while her parents were living at Kangaroo Point, her father again practising as a solicitor. Her parents did not stay long; they returned to England in 1857 and settled in Bath, Somerset where her father became an emigration agent for Queensland (*Bristol Mercury*, 5 August 1865, extracted from British Library Newspapers). Their departure was followed by the deaths of Elizabeth's three brothers, in at least one case due to tuberculosis: Frederick Edward Isaac died in

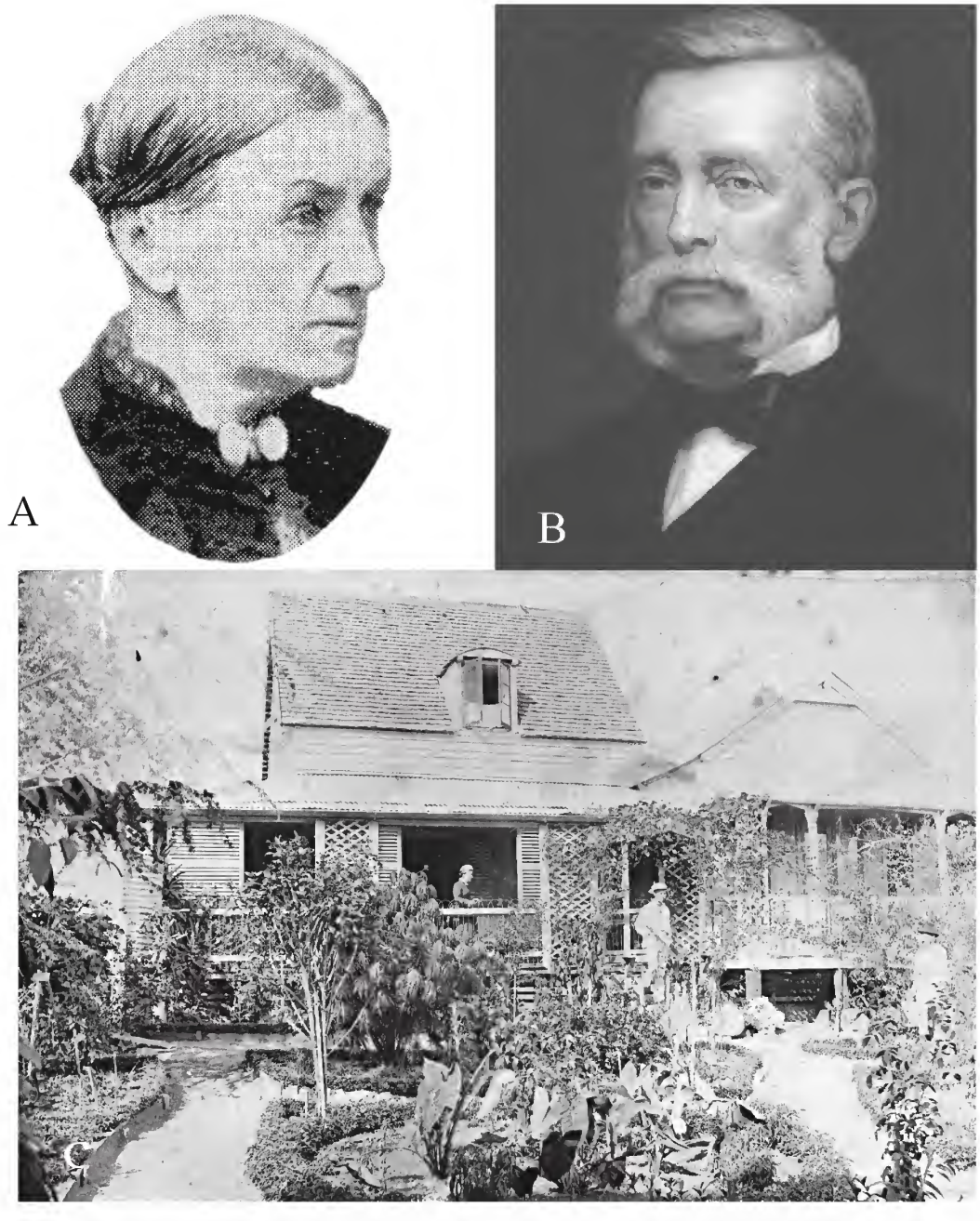


FIG. 1. **A**, Elizabeth Coxen—note her sea shell 'butterfly' brooch, possibly made from Moreton Bay venus clam valves, indicating her interest in shells (From a booklet on St John the Baptist Church, Bulimba, held by the Anglican Diocese of Brisbane Records and Archives Centre). **B**, Detail of a portrait of Charles Coxen by Dickinsons of London (Queensland Museum collection – for full portrait see Fig 9). **C**, Omega Cottage in Church Street, Bulimba, January 1886, with Elizabeth on the verandah (From Elizabeth Coxen's photograph album, APO-17, John Oxley Library, State Library of Queensland).

1861 at Deepwater, Maranoa, one of Coxen's runs; Henry Edward Isaac died in 1862 back in England, having returned in the hope of regaining his health; while Frederick Neville Isaac died in Brisbane in 1865. No doubt the departure of her parents and premature deaths of her brothers and eventually her husband would have left Elizabeth feeling isolated as much as bereft, contributing to the resilience that would characterise her later life.

At Bimbian, life would have been tough for Elizabeth Coxen. Not only cut off from civilisation, she would have lived in a slab hut, which was then standard accommodation even for larger stations like Gowrie, and the station would have been under constant threat of Aboriginal attack, a situation that had forced her brother Frederick off the neighbouring Dulacca (obituary of Frederick Neville Isaac, *Brisbane Courier*, 15 July 1865). By way of consolation, Elizabeth would have been able to indulge her passion for natural history, as an early account of Coxen's life states that at this time she began assisting him with his collecting activities (Leavitt 1887). The Coxens soon had to leave Bimbian due to Charles's ill health. After spending some time in Brisbane while he recovered, they moved to a less remote station, Daandine, near Dalby. During their six years at Daandine Coxen became Dalby's magistrate and, in 1860, was elected as member for the Northern Downs in Queensland's first parliament. He held the seat until 1867, by which time he had given up squatting, though he continued to hold some runs into the mid-1860s.

In 1861 the Coxens returned to Brisbane, settling at The Terraces overlooking the river at Murarrie, an extensive property of 84 acres which Charles had purchased from 1854. The property was partly under cultivation, with a commodious stone residence and outhouses, commanding a magnificent view of the river extending from Breakfast Creek almost to Lytton (sale notice, *Brisbane Courier*, 1 July 1868). It was on the opposite bank of the river from Coxen Point, named after them, where the Royal Queensland Golf Club is now located. The garden was laid out in terraces stepping down to the river's edge where there was an old coal mine hence the property was also called The Quarries. While living at Murarrie the Coxens took an active interest in local affairs, joining with other residents to lobby for better roads and, as devout Anglicans, leading the campaign for a church to serve the area. Christ Church, Tingalpa, designed by Brisbane architect R.G. Suter, opened in 1868; however the present church located in Wynnum Road and now on the Queensland Heritage Register is a replacement of the earlier building destroyed in a cyclone of 1885. Charles Coxen was also a foundation member of the Tingalpa branch of the East Moreton Farmers' Association established in 1867 to promote agricultural activities in the district.

Already by late 1864 Coxen was suffering financial difficulties and had to mortgage The Terraces, taking out a second mortgage in 1866. In 1867 he sold the property to Dr Hugh Bell, a pioneer Brisbane medical practitioner, who in turn sold it in 1883 to the Premier Sir Thomas McIlwraith and his trustees. Meanwhile, Coxen with his influential connections was able to secure government employment: from 1868 as Land Commissioner for the East and West Moreton districts, and then from 1872 as Land Commissioner for the East Moreton district and Inspecting Commissioner for the settled districts of the colony; he held these latter posts until 1876. After leaving The Terraces the Coxens moved to a more modest dwelling nearer town, a timber cottage known as Omega Cottage, located in Church Street (now Birkalla Street) near the river at Bulimba (Fig. 1C). Though Coxen had off-loaded much of his Brisbane property during the late 1860s, he still held a number of blocks in Bulimba and Kangaroo Point. Despite their straightened circumstances, the Coxens remained public-spirited citizens, providing annual 'tea-feasts' for local children at which Elizabeth would distribute books and toys (*Brisbane Courier*, 1 January 1876). Elizabeth, described by Charles's nephew Henry William Coxen as 'intelligent and pleasant', loved children and always made them welcome at Omega Cottage. She became known as 'the

TABLE 1. Animal species named after Charles or Elizabeth Coxen.

Original Name	Type locality	Current Name	Original publication
MOLLUSCA			
Pupina coxeni (operculate land snail)	'Mount Dryander, Port Denison, N.E. Australia'	*Signepupina coxeni* (Brazier, 1875)	Brazier, 1875
Helix (Hadra) *coxenae* (land snail)	'Johnson river [sic], Queensland' (= Johnstone River)	*Spurlingia dunkiensis* (Forbes, 1851)	Brazier, 1875
Conus coxeni (marine cone snail)	'Moreton Bay'	*Conus cyanostoma* (A. Adams, 1855)	Brazier, 1875
Helicina coxeni (operculate land snail)	'Yule Island, New Guinea'	*Palaehelicina coxeni* (Brazier, 1875)	Brazier, 1876
Helix coxeni (land snail)	'Whitsunday Island, Queensland'	*Gloreugenia coxeni* (Cox, 1871)	Cox, 1871
Cypraea coxeni (marine cowrie)	'Solomons'	*Eclagavena coxeni* (Cox, 1873)	Cox, 1873
Cythera coxeni (marine venus clam)	'Port Molle, Queensland'	*Pitar coxeni* (E.A. Smith, 1884)	E.A. Smith, 1884
VERTEBRATA			
Cyclopsitta coxeni (fig parrot)	none stated	*Cyclopsitta diophthalma coxeni* (Gould, 1867)	Gould, 1867
Halmaturus coxenii (pademelon marsupial)	'North Australia, Port Albany'	*Thylogale stigmatica coxeni* (Gray, 1866) or *Thylogale stigmatica* (Gould, 1860)	Gray, 1866

mother of Bulimba' (Anon. 1906). The Coxens had no children of their own.

In Brisbane, the Coxens maintained their love of natural history, with Elizabeth taking a particular interest in conchology and Charles focussing more on ornithology and taxidermy. Fittingly, both were honoured by having new species named after them by Australian and English scientists based on material from the Coxen collections, including a parrot, a marsupial and a number of molluscs (Table 1, Fig. 2). According to Henry William Coxen, 'The pair frequently "roughed it" together on natural history hunts in Moreton Bay—long before it was thought proper for ladies to do so.' Elizabeth later wrote of their boating trips to collect shells from around the bay. She recounted how they would keep live cowries in a vessel of water in their boat, as it had been Charles's intention to make wax models of the curious animals inhabiting the shells, and then to place these in the shells of the respective species; however illness had prevented him from carrying out his project (Coxen 1894b). She took an interest in the Queensland Philosophical Society, founded in 1859 by Coxen and others to promote the study of natural history in the colony. In 1875 Elizabeth became the only woman ever to attend one of the society's meetings, accompanying her husband to the meeting of December 1875 (Marks 1960); this was to be the last he was to attend as his health was failing. He died at Omega Cottage, Bulimba several months later, on 17 May 1876, leaving a small estate of £500.

Following Charles Coxen's death Elizabeth continued to live at Omega Cottage and maintained her scientific interests, including undertaking curatorial work for the Queensland Museum, as will be discussed later. Her work for the museum continued until 1882 when she visited England. In April that year she sailed for London, travelling saloon class, which suggests that her financial position had improved. In recent years her parents had died so possibly she had received an inheritance, and since Coxen's death she had been selling off some of

FIG. 2. Preserved skins of Coxen's Fig Parrot (*Cyclopsitta diopthalma coxeni* Gould, 1867), Queensland Museum Collection. Charles Coxen had provided English ornithologist John Gould with his notes and an accurate drawing, but disappointingly Gould's description was not accompanied by any illustration.

his land in Bulimba and Kangaroo Point. While in England, Elizabeth undertook an assignment for the museum: a report in the *Brisbane Courier* of 26 May 1882 states that she procured a supply of artificial eyes for bird mounts. Her photograph album, now preserved in the John Oxley Library, records that during her stay in England she also visited the Natural History Museum in London and witnessed a violent storm that lashed the coastal city of Hastings in September 1882; and it was probably at this time that she commissioned a portrait of Coxen. On her return to Brisbane, Elizabeth kept up her scientific work more vigorously than ever. During the 1880s she donated many specimens to the Queensland Museum, not only shells but such diverse material as crabs, a freshwater turtle, sea urchins, birds, insects, a death adder, fungi and lichens. These indicate the range of her curiosity as a naturalist. She also developed the garden at Omega Cottage and added a meteorological station to pursue her newfound interest in rainfall and climate.

In December 1886 Elizabeth Coxen was elected as a member of the Royal Society of Queensland, making her the first woman member of a local scientific organisation (Marks 1960). This society, founded three years earlier to promote 'the furtherance of Natural Science' in the colony, was successor to the previously-mentioned Philosophical Society. In November 1893, Elizabeth became the first woman to read a paper to the society, her subject being cowrie

shells (Marks 1960; see Coxen 1994b). Also at this time she gave a paper on Brisbane's floods (Coxen 1894a), written in the wake of the disastrous flood of February 1893 which she witnessed at first hand (Fig. 3A). At Bulimba, she reported, the water rose to 12 feet above ordinary high tides and probably Omega Cottage was inundated as about this time she moved temporarily to another house around the corner. She kept attending Royal Society meetings until 1899 and tabled no fewer than twelve papers, mostly weather reports, which are published in the society's Proceedings (Coxen 1889a, b; 1891; 1894a–d, 1896, 1897, 1898, 1899a, b). By the 1890s she was joined by other women members, most of whom were school teachers and included Eliza Fewings, founder of the Brisbane High School for Girls (later Somerville House).

In her later years Elizabeth maintained her support for the Anglican Church. In early 1887 she put up a notice near the Bulimba ferry calling a meeting of local residents, to be held at Omega Cottage, to initiate the building of a church for the area (*Telegraph*, Brisbane, 30 July 1887). To this end, she gave the Diocese of Brisbane a block of land in Church Street and started a subscription list by giving £100. Later this land was sold and the present more central site in Oxford Street was purchased. St John the Baptist Church, Bulimba, designed by the Diocesan Architect J.H. Buckeridge, was opened in September 1888 and is now on the Queensland Heritage Register (Fig. 3B). In the following year Elizabeth gave the Diocese another block of land, this time in Brisbane Street and valued at £300, to be mortgaged and the proceeds put towards building a rectory for the local clergyman, and, in return, the Synod was to pay her an annuity of £18 during her lifetime. This land was also sold, but not until after her death. The Diocesan newspaper, the *Church Chronicle*, records that Elizabeth was one of Bulimba's most active parishioners: making Omega Cottage available for church meetings, helping with fetes and other functions, providing prizes for annual Sunday school picnics, contributing funds, even making church vestments (*Church Chronicle*, 1 February 1893).

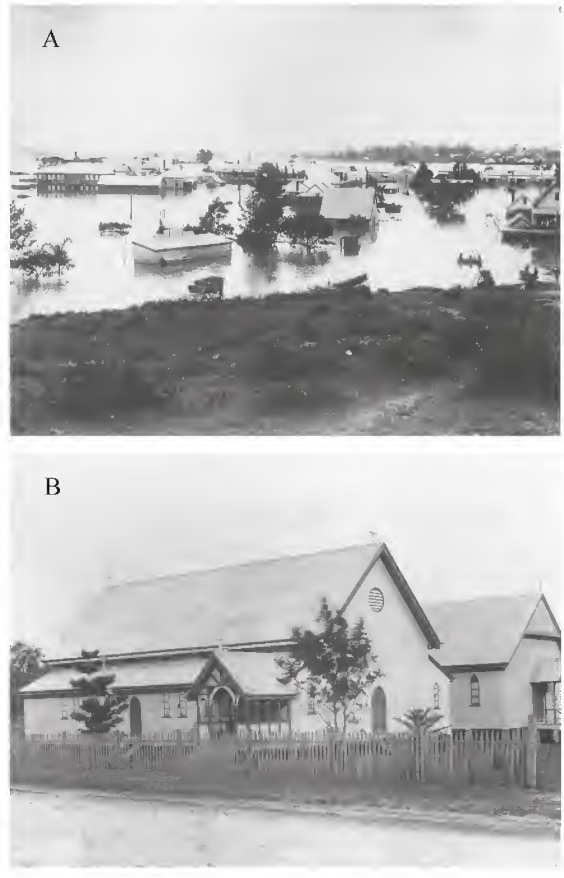


FIG. 3. **A**, Flood on the Brisbane River at Bulimba, 1893. **B**, St John the Baptist Church, Bulimba, instigated by Elizabeth Coxen and opened in 1888 (Both from Elizabeth Coxen's photograph album, APO-17, John Oxley Library, State Library of Queensland).

At the turn of the twentieth century Elizabeth Coxen's health began to fail, so she moved to the care of friends, Mr and Mrs Benson Hall, who had been fellow Bulimba residents and also keen gardeners (*Brisbane Courier*, 24 July 1906). She died at the Halls' Teneriffe home on 11 August 1906 at the age of 80 years. Later she was buried beside her husband in Tingalpa Cemetery in the grounds of Christ Church. The Coxen graves are among those of other pioneers in the picturesque churchyard. In 2003 the Friends of Tingalpa Cemetery Heritage Group restored the graves and the Queensland Museum provided a new memorial plaque.

Elizabeth is also remembered by a handsome timber lectern presented in 1907 by her friends to St John the Baptist Church, Bulimba, the church she had so generously supported.

Conchologist and Museum 'Curator'

The Coxens' and Queensland Museum Shell Collections

By the 1860s the Coxens had already amassed a large shell collection. In September 1867, when a newspaper reporter visited them at The Terraces, Murarrie, he commented on their collection of shells and marine flora all 'scientifically arranged and classified' (*Queensland Daily Guardian*, 19 September 1867). When shown several years later in an exhibition at the Brisbane School of Arts, the collection again attracted attention: 'The conchological treasures of Mr Coxen are contained in twenty-six trays, and comprise 1350 specimens of very rare and beautiful shells. ... They deserve more than a passing notice, if for no other reason but because the collection has been made with the view of presenting it, or duplicates of many of its objects, to our National Museum' (*Queenslander*, 22 November 1873). Likewise, in January 1876, when the young Scottish naturalist James Whitelaw Craig visited the Coxens at Bulimba, he mentioned their 'very extensive' shell collection (Craig, 1908). In the Queensland Museum's annual report for 1875, custodian Karl Staiger (February 1876) noted that 2000 specimens of shells, representing 1405 species, were on display during the year, and that all had been donated by Charles Coxen; Coxen, he added, was willing to donate a further 1500 specimens 'as soon as space can be found for their exhibition'. Staiger also stated that the 'arrangement of the shells' (presumably the systematic arrangement of them) was the result of Elizabeth's Coxen's considerable efforts.

From the above evidence it seems that the Coxens' shell collection contained at least 3500 specimens, possibly many more; however it remains uncertain whether the 1500 specimens pledged to the Queensland Museum in early 1876 were eventually donated or (more likely) sold by Elizabeth following her husband's death. Though contemporary accounts credit Charles as the driving force behind the collection, there is little doubt that both he and Elizabeth shared a passion for molluscs and their shells and embarked on many collecting trips together, particularly within Moreton Bay. Elizabeth's photograph album includes images of Dunwich on Stradbroke Island and John Brazier (1879), using Coxen's unpublished notes on cowries, mentions the following collection locations within the bay: Amity Point, Myora (both on Stradbroke Island), Peel Island, Burleigh Heads and Caloundra. The collection, in its size and apparent diversity, was the outcome of their joint collecting efforts, their scientific and personal connections and purchases from overseas dealers. In fact, Monteith & Mather (1986) have suggested that the shell collection may have been Elizabeth's domain rather than Coxen's as his interests were largely centred on ornithology and taxidermy. Certainly Staiger's annual report of 1875 confirms Elizabeth's expertise with molluscs.

That the Coxens had many important contacts in the scientific world, including within the sphere of malacology (or conchology as it was usually termed at this time and will be used in this paper) is evidenced by papers published by such notable scientists as John Brazier (1875, 1876, 1877), James Cox (1871, 1873) and Edgar A. Smith (1884) (Fig. 4A–C). Between them, these three authors named species of marine or terrestrial molluscs and a marine bivalve mollusc after either Charles or Elizabeth (Table 1 and Figs 5, 6). Brazier's 1875 paper title actually states that his material came from Charles Coxen's shell collection, although interestingly the type specimens associated with that paper were lodged with the Australian Museum in Sydney rather than the Queensland Museum [the holotype of *Conus coxeni* cannot be located in either museum's molluscan collections and was possibly deposited elsewhere]. We also know from the Queensland Museum archives that Elizabeth exchanged specimens from Queensland with the prominent English conchologist Sylvanus Hanley, author of important taxonomic papers and books on molluscs such as the

FIG. 4. Notable molluscan workers who corresponded with or benefitted from material from the Coxens. **A**, John Brazier (Australia) (from Iredale, 1930; Australian Museum); **B**, James C. Cox (Australia) (from Walkom, 1925; Linnean Society of NSW); **C**, Edgar A. Smith (England) (from Dance, 1966; Conchological Society of England and Ireland); **D**, Charles Hedley (Australia) (from Walkom, 1925; Linnean Society of NSW).

FIG. 5. Hand-coloured plate from Brazier (1875) showing holotypes of ten species described from specimens supplied by the Coxens to John Brazier (Queensland Museum Library). Their original names are: 1. *Helix (Hadra) mourilyani*; 2. *H. (H.) johnstonei*; 3. *H. (H.) hilli*; 4. *H. (H.) bellenden-kerensis*; 5. *H. (H.) coxenae*; 6. *H. (H.) mossmani*; 7, 7a. *H. (Rhytida) sheridani*; 8. *H. (Xanthomelon) daintreei*; 9. *Pupina coxeni*, 10. *Conus coxeni*). A number of these species names have since disappeared into synonymy (see Table 1; also Stanisic *et al.*, 2010). The pencilled-in species names were added by Dr John Shirley of the Queensland Museum (Honorary Conchologist 1912–1914, Conchologist 1920–1921).

Index Testaceologicus and *Conchologica Indica*. Presumably those specimens are still in the Leeds Museum Discovery Centre where most of Hanley's large collection and associated notebooks and other archival material resides (Rebecca Machin, pers. comm. to JMH). She also exchanged specimens with London's Natural History Museum (NHM) which, as mentioned earlier, she made a special point of visiting in 1882. The specimens exchanged with the NHM included species named after herself or Charles; recent checking has confirmed their existence (see Table 1). Elizabeth Coxen had recognised the need for the Queensland Museum to obtain specimens of foreign species to exhibit here and also the need to have shells of our own indigenous species represented in the great museums of other countries. Given the increasing importance of biosecurity in modern Australia - and therefore the need for prompt and accurate identification of potential or actual invasive species—her view that local museums should have specimens of foreign species in their collections seems prophetic. One of the strengths of the Queensland Museum's current mollusc collection is its strong representation of foreign species, and this material has often proved crucial for identifying invasive species. As Elizabeth would have been aware, illustrations in books and papers rarely convey all the subtleties of form and colour of actual specimens, nor are they any substitute when it comes to educating the public.

Curator of Conchology

Just before his death on 17 May 1876, Charles Coxen conveyed a message to the Queensland Museum's Trustees proposing that the museum purchase 'certain books, bird skins etc.' and 'expressing Mrs Coxen's wish to continue her connection with the museum at the price of a small remuneration' (Trustees' Minutes, 18 May, 1876) [Unfortunately, Coxen's communication, assuming it was written rather than verbal, is missing from the museum's archives, hence we must rely on the wording of the minutes]. Although not expressly stated in the minutes, it was undoubtedly Coxen's wish for Elizabeth to continue her care of the museum's shell collection, to which the couple had so generously contributed through their donations of specimens and time. While the Trustees agreed to purchase the Coxen collection material and books, the proposed employment of Elizabeth met with some resistance, particularly from William Miskin, a solicitor of punctilious disposition. The Trustees' Minutes of 24 January 1877 record that: 'he thought that such an appointment would be most injurious and calculated to be subversive of the future systematic working of the institution and that it was really unnecessary. It would be much better for the Trustees to call on Mrs Coxen's assistance at such times as might be found necessary for which she should be remunerated, but that no fixed appointment ought to be made.' Miskin did, however, recommend that £50 be set aside for 'any service that might be required on behalf of the museum during the following twelve months and that it be further represented to the Government that in the opinion of the Board no appointment should be made to the museum without being first submitted to them for consideration and approval at one of their meetings.....'

While it is understandable that Miskin was trying to be careful with museum and therefore government funds, it is also clear that the Coxens' intentions had been misunderstood. Charles Coxen had never sought a permanent post, curatorial or otherwise, for his wife; simply some 'small remuneration' for maintaining the shell collection. He himself had only ever been an honorary curator, and museum records of the 1870s and 80s show that it lacked the financial capacity to employ more than one paid curator at any given time. Elizabeth Coxen's expertise with molluscan shells was well recognised and the prospect of her continued involvement with the museum was applauded in the local press. The *Queenslander* newspaper of 3 February 1877 reported: 'It is rumoured that the widow of the late Charles Coxen, Esq., who is well up in conchology, will assist in setting up this branch of science in the museum.' But shells, despite their appeal to the general public, inevitably would be viewed as less important

FIG. 6. Shells and living specimens of molluscan species named after Charles or Elizabeth Coxen (from the Queensland Museum collection). **A**, Shells. Land snails: (1) *Spurlingia dunkiensis* (Forbes, 1851) (formerly *Helix coxenae* Brazier, 1875); (2) *Gloreugenia coxeni* (Cox, 1871). Operculate land snails. (3) *Signepupina coxeni* (Brazier, 1875); (4) *Palaehelicina coxeni* (Brazier, 1876). Marine snails: (5) cowrie *Eclogavena coxeni* (Cox, 1873), (6) cone *Conus cyanostoma* A.Adams, 1855 (formerly *Conus coxeni* Brazier, 1875). Diameter of (1) 32 mm; **B**, Live *Spurlingia dunkiensis* (Forbes, 1851) (photo : John Stanisic); **C**, Live *Signepupina coxeni* (Brazier, 1875) (photo: Darryl Potter); **D**, Live *Conus cyanostoma* A.Adams, 1855 (photo: Don Byrne).

than birds, mammals, insects or even minerals, and therefore unworthy of a formal curatorial position. Eventually the museum agreed to hire Elizabeth on a daily basis (10 shillings per day attended) but without any formal title; this was not only to maintain the shells but also to assist with other collection duties.

In 1877, when Elizabeth Coxen officially assumed responsibility for the Queensland Museum's shell collection, undoubtedly many of the specimens she was to oversee had come from her and her husband's own collection, either by donation or purchase. In a ledger preserved in the Queensland Museum's Rare Book Collection ('Mrs Coxen's List'), Elizabeth records 942 named species of molluscs together with basic locality and, if known, specimen source information (Fig. 7). Almost certainly this is a catalogue of the museum's mollusc

collection compiled while she was employed by the museum (1877–1882), as it is entirely in her hand and includes a short preamble signed by her. The ledger mentions several notable scientists or collectors of the era, such as Hargraves, Thatcher, Jardine, Le Grand, Cox, Brazier, Stutchbury and Bednall, and through these names we can develop some idea of the Coxens' wide circle of Australian and overseas natural history contacts and colleagues. Some of the entries in the list bear the donor initials 'CC', suggesting that such specimens had come from Charles Coxen. The ledger shows that the museum's mollusc collection covered many of the important marine mollusc groups: gastropods, such as cones, strombs, cowries, mitres, olives, helmets, murexes; bivalves, such as pearl oysters, venus clams, giant clams, mussels; chitons; some cephalopods; and at least four of the seven molluscan classes. As much of the collection at the time would have been on public display, emphasis was given to the larger, more colourful Indo-Pacific species, but many foreign species and common species from Moreton Bay were also represented. Looking now through the range of species in 'Mrs Coxen's List', it is obvious why sea shells were always a major attraction for museum visitors as evidenced by newspaper items of the time (e.g. *The Queenslander,* 25 September, 1875, 6 April, 1878).

Sadly, few specimens bearing definite Coxen provenance have been located to date in the Queensland Museum's present mollusc collection (Fig. 8). Some Coxen specimens may have lost their original labels (through insect or water/humidity damage) and been re-labelled without donor information, while others may have been exchanged with other institutions, or simply deteriorated over time and subsequently culled. Given that the museum has occupied at least five premises since the 1860s, some loss of Coxen shells was almost inevitable. Past exchanges would seem the most likely reason for the scarcity of Coxen material from today's collection, as the Registers of Exchange record several out-going transactions in which Queensland shells (many from Moreton Bay where the Coxens had personally collected) were sent overseas. From Elizabeth Coxen's surviving correspondence we know that she actively pursued foreign shells for the museum via exchange, as she had done earlier in her career and was to continue later. Exchange was standard practice in her day—virtually all world museums utilised this method of expanding the diversity of their natural history collections as it avoided at least some of the need for purchase funds.

Apart from compiling the previously-mentioned collection ledger, Elizabeth Coxen appears not to have prepared any formal scientific papers relating to molluscs during her five-year employment by the Queensland Museum. She did, however, supply John Brazier with her late husband's unpublished notes relating to the cowries of Moreton Bay (and associated collection localities), which became the whole basis of Brazier's annotated list of species (see Brazier 1879). Possibly Elizabeth saw her role more as maintaining the collection, adding to it through her wide circle of contacts, and facilitating the work of established scientists. Also, given her success in public displays of specimens, at international exhibitions, fund-raising events as well as the museum (*Brisbane Courier*, 2 November 1895), it seems likely that she saw such displays as her most important contribution to the study of molluscs or invertebrates in general. Another aspect of her museum work would have been dealing with inquiries relating to the shell collection and invertebrates generally, however little evidence of this survives in the museum's archives.

Elizabeth Coxen's only known contributions to the scientific literature relating to malacology are two short papers dating from after her museum employment and read to meetings of the Royal Society of Queensalnd which, as previously explained, she was the first woman member. The first of these papers was on cowries (Coxen 1894b), based partly on her late husband's unpublished notes on the living animals, while the other was on the dangers of living cone snails (Coxen 1894c). Given Elizabeth's life-long passion for molluscs and their shells, her lack of publications in this field

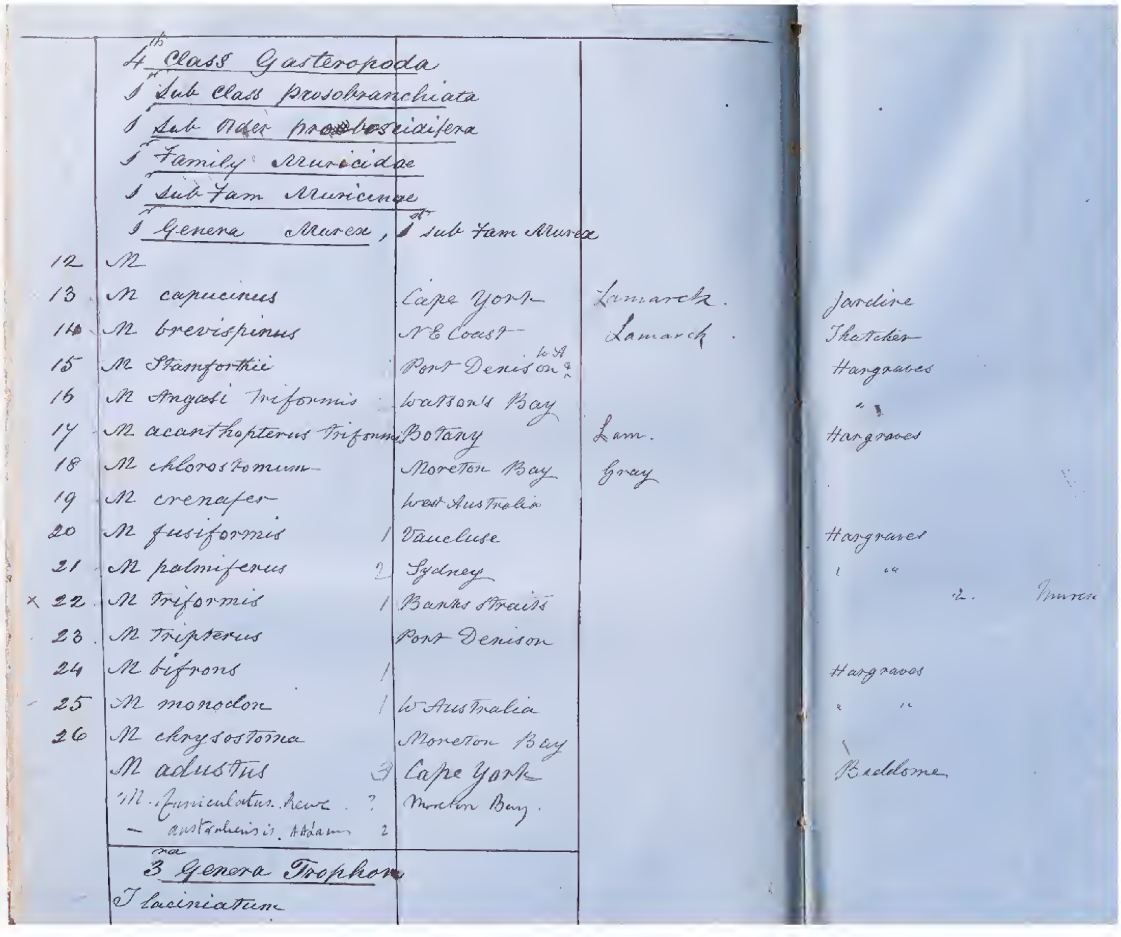


FIG. 7. 'Mrs Coxen's List', the earliest known catalogue of the Queensland Museum's molluscan collection (Rare Book Collection, Queensland Museum Library). Although undated, this ledger of specimens is written entirely in Elizabeth Coxen's hand, with a brief preamble signed by her (simply as 'Coxen'). Similar ledgers ('Hedley's List' by a later curator of molluscs Charles Hedley, and museum collector 'C.J. Wild's List') are also held by the Queensland Museum, indicating that 'Mrs Coxen's List' was almost certainly drawn up during her employment by the museum (1877–1882).

may seem surprising. However, in her day there would have been reservations about a woman actively publishing scientific work, as women were only beginning to take up scientific studies at Australian universities, though not yet in Queensland (McKay 1997). Also, obtaining current publications pertinent to the subject was always a problem for Australian researchers, especially those living outside the southern capitals, so Elizabeth would have had, at best, only limited access to the wealth of information published on molluscs during the late nineteenth century. Indeed her successor at the Queensland Museum, John Shirley, was to resign his post in 1914 lamenting that the lack of key taxonomic works prevented him from undertaking research on the mollusc collection (Monteith & Mather 1986).

Although Elizabeth Coxen was never given the formal title of 'curator', we believe that, by virtue of the work she undertook, she largely fulfilled this role and should be seen as the Queensland Museum's first Curator and/or

Collection Manager of Molluscs (Conchology). In her official history of the museum Dr Patricia Mather (1986) lists Elizabeth as 'part time Conchologist' in her summary of the early staff, however we have not been able to confirm this title in contemporary records. Elizabeth was certainly the first person—male or female—to be paid to oversee any part of the museum's invertebrate collections, and was probably the first woman curator of any natural history museum in Australia.

From 1882, when Elizabeth Coxen's employment by the Queensland Museum ended, the shell collection was overseen by various honoraries and/or collectors, such as Henry Tryon, Kendall Broadbent and C.J. Wild, until Charles Hedley was appointed as a temporary 'conchological assistant' in 1888 (Monteith & Mather 1986) (Fig. 4D). According to those authors, Hedley 'completely rearranged the collection and donated a collection of his own' and in 1889 he contributed much material from his collecting in New Guinea as part of the William MacGregor expedition. He also compiled another ledger of the shell collection ('Hedley's List'), more detailed than Elizabeth's earlier ledger but no doubt drawing on it. Hedley would have known Elizabeth as they were fellow members of the Royal Society, and on one page of his collection ledger he made specific mention of her in relation to the identification of a species. Hedley left the museum in 1890 for a spectacularly successful 33-year career as a scientist and notably conchologist at the Australian Museum (Fairfax 1983). Monteith & Mather (1986) record that following his departure the shell collection remained largely untended until the honorary conchologist Dr John Shirley was appointed in 1912. To what extent Elizabeth Coxen interacted with the museum in her later life is uncertain, although her continuing donations suggest a cordial relationship.

FIG. 8. Two rare lots of gastropod shells with labelled Coxen provenance: **A**, *Cymbiola pulchra* (G.B. Sowerby I, 1825) 'N.E. Australia' [this is the form found at Heron Island, Great Barrier Reef]; **B**, *Conus cyanostoma* A.Adams, 1855 (formerly *C. coxeni* Brazier, 1875) from Moreton Bay.

Horticulturist

After returning from her visit to England in 1882, Elizabeth Coxen devoted more time to her other interests, notably gardening, an interest she had shared with her late husband. Their garden at The Terraces, Murarrie, was said to be 'the very embodiment of horticultural loveliness' (*Queensland Daily Guardian*, 19 September 1867). It featured a series of flower-laden terraces which descended down to the river to terminate in an arbour of ornamental and fruit-bearing trees; this was reached by stone steps winding around rocks and boulders 'placed in the most admirable disorder'. Though the Coxens employed resident gardeners, Elizabeth undertook much of the gardening herself. According to the diary of Bertha Pears, a pioneer settler of the area, 'tiny old Mrs Coxen' was often to be seen digging

until late. Besides their garden, the Coxens had grapes and sugar under cultivation at The Terraces, being experiments into the successful introduction of these products to Queensland. As a parliamentarian Charles Coxen advocated agricultural development, favouring liberal land laws to allow farmers to take up country lying idle under pastoral leases. As mentioned earlier, he was a foundation member of the local branch of the East Moreton Farmers' Association; as well, he was a foundation member of the Queensland Horticultural Society and the Acclimatisation Society which also promoted agriculture. No doubt Elizabeth would have supported her husband's agricultural interests; however his liberal views would not have been shared by many other squatters and probably contributed to his electoral defeat in 1867. For instance, Elizabeth's brother Frederick was one of the Darling Downs's most notorious land-grabbers, using dummying and pre-emptive purchase to monopolise 2200 acres of land and so prevent farming near Gowrie.

The Coxens showed produce from The Terraces in Brisbane's earliest horticultural exhibitions, held from 1862 by the Horticultural Society. In 1864 Elizabeth showed 'a good collection of petunias, verbenas, fuschias and balsams' and won prizes for a table bouquet and beeswax (*Brisbane Courier*, 16 January 1864). The Coxens also donated seeds and plants to the Acclimatisation Society, a practice continued by Elizabeth after Charles's death. In 1875 she gave seeds of the 'lady apple' tree (*Syzygium suborbiculare*) from Cape York Peninsula, indicating the depth of her interest in plants (*Queenslander*, 25 December 1875). Surprisingly, though the Acclimatisation Society had several women members by the 1870s, there is no evidence to suggest that Elizabeth ever joined.

In later life Elizabeth Coxen made her smaller garden at Omega Cottage, Bulimba a showplace. At this time she was assisted in her efforts by another prize gardener from Bulimba, Mr C. Rosenthal. Besides maintaining her donations to the Acclimatisation Society, Elizabeth continued exhibiting, now in Brisbane's annual exhibitions organised by the National Agricultural and Industrial Association. Between the years 1881 and 1887 she was a regular exhibitor in the exhibitions' horticultural sections, mostly showing cut flowers, pot plants, fruit and vegetables. In 1886 she was the main horticultural exhibitor (Scott 2008), her exhibits including a 'collection of not less than 24 varieties' of cut flowers.

In 1886, in an essay on medicinal plants, the eminent medical practitioner and naturalist Dr Joseph Bancroft included mention of *Eucalyptus staigeriana* F. Mueller ex Bailey, 1883, the Lemon Ironbark from North Queensland, the foliage of which is rich in lemon-scented oil. Bancroft wrote: 'The only tree of this species, in Brisbane, grows in the garden of Mrs C. Coxen, a lady who has assisted materially in the furtherance of this study of natural history' (Bancroft 1886).

Meteorologist

Besides gardening, Elizabeth Coxen devoted time to her newfound interest in meteorology. In January 1883 she began compiling monthly weather reports at her home in Bulimba, using her own meteorological station to record temperatures and rainfall. In doing so she became a pioneer of climate science in Queensland, predating the establishment of the colony's official weather service in 1887 with the appointment of meteorologist Clement Wragge. By 1889 Elizabeth was using the initials 'MRMS' after her name, indicating that she was a proud member of the Royal Meteorological Society of London. By this time there were many other meteorological stations across Queensland, however most of the observers were government officials, not private citizens, and presumably they were male. Elizabeth's meteorological work would have been onerous as generally observations were taken thrice daily. Between 1889 and 1899 she published several tabulated rainfall and temperature reports (Coxen, 1889a,b, 1891, 1896, 1897, 1898, 1899a,b) and a paper on Brisbane's floods. The latter, written in the wake of the city's worst flood on record, reflected community interest in rainfall and its often dramatic consequences (Coxen 1894a). Sometimes Elizabeth recorded maximum and minimum temperatures for all

FIG. 9. Portrait of Charles Coxen, Founder of the Queensland Museum, oil on canvas, c 1883, by Dickinsons of London, donated by Elizabeth Coxen to the Queensland Museum in February 1887 (Queensland Museum Cultures and Histories collection, H42666).

Australia's capital cities over recent years, suggesting that she was corresponding with colleagues in other colonies. Her meteorological reports are now preserved in the archives of the Royal Society and the Queensland Museum.

Honouring Charles Coxen

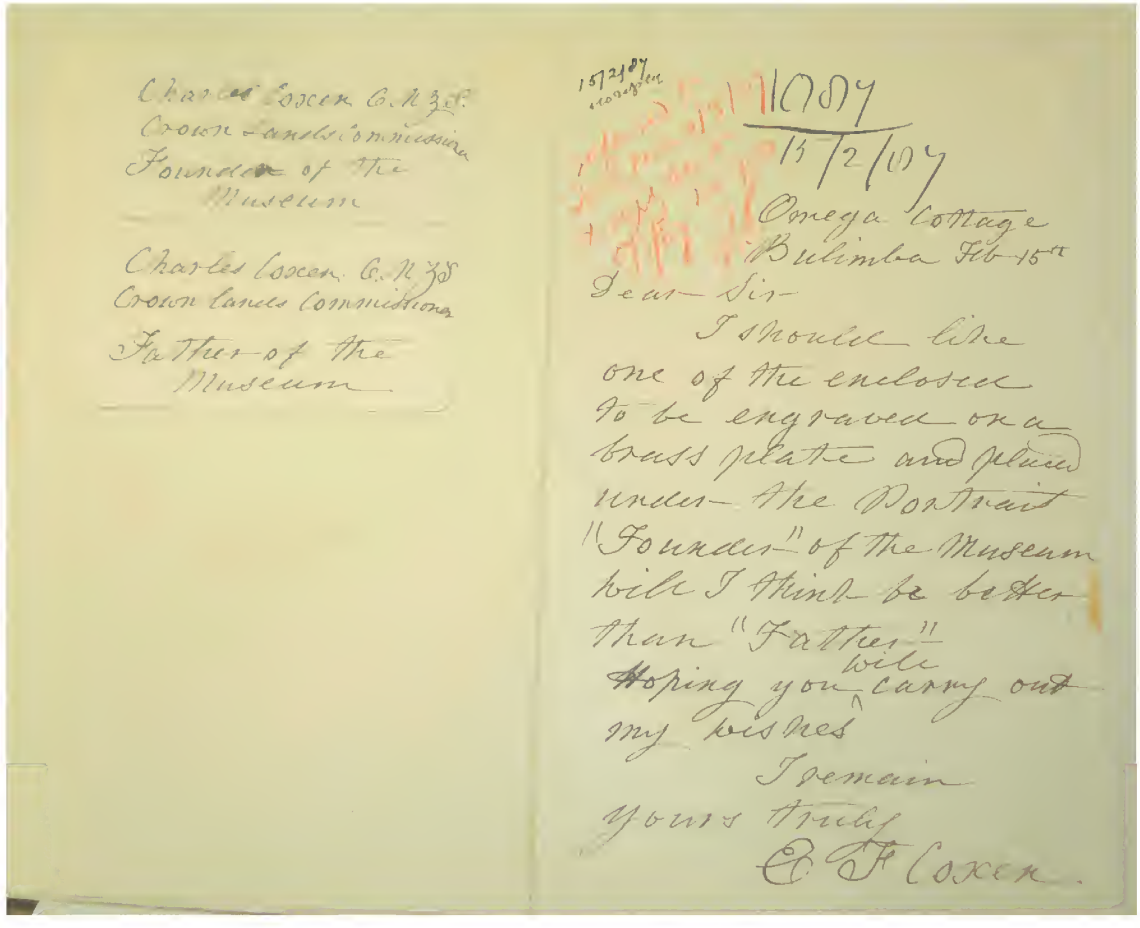
Elizabeth Coxen maintained her late husband's interest in international exhibitions; he had been one of Queensland's commissioners for several exhibitions in London and Paris between 1862 and 1871. She contributed to Queensland's exhibits at the Sydney exhibition of 1879 and to Melbourne's event of the following year, showing shells and mounted birds. The birds—rifle birds, regent birds and bowerbirds—had been artistically mounted by Charles Coxen and contained in handsome yellowwood and cedar cases. They won a first degree of merit at Sydney. However, on return from Melbourne three of the cases of birds, along with the shells and many other exhibits, were badly damaged by defective packing, resulting in an insurance claim (McKay 1998). This would have been distressing for Elizabeth as the birds were prize examples of Coxen's skill in taxidermy, ones that she had kept in her own possession.

In 1887 she donated a portrait of Charles Coxen to the Queensland Museum (Fig. 9) (Donation 4258). It is a large and impressive oil portrait depicting him in later life when he was a land commissioner, and set in an ornate gilt frame. According to the museum's Trustees' Minutes of 3 March 1887, the portrait was painted by an artist called 'Dickinsny' (sic) but no other information was recorded. However, when the portrait was conserved in recent years, the true maker was revealed as Dickinsons of New Bond Street, London—'by appointment to the Queen'. Dickinson Brothers was one of England's most fashionable portrait studios of the Victorian era. Its master, Lowes Cato Dickenson (1819–1908), was a regular exhibitor at London's Royal Academy and could number such notables as the Queen, Cabinet ministers and colonial governors among his sitters. From the studio address, the Coxen portrait can be dated to after 1882, which suggests that Elizabeth would have commissioned it during her visit to England. Presumably it was painted from a photograph, which is still standard practice for portraying deceased subjects. Whatever the circumstances of its commissioning, the portrait would have been very costly, again indicating Elizabeth's rise in fortunes at this time.

On 15 February 1887, when she gave the portrait to the museum, Elizabeth wrote to ask that a brass plaque be affixed with the words 'Charles Coxen CMZS [corresponding member of the Zoological Society], Crown Lands Commissioner, Founder of the Museum', or alternatively, 'Father of the Museum' (Fig. 10). But the then Trustees refused to accept either title and changed the wording to 'Charles Coxen Esq. CMZS, first honorary curator, one of the earliest Trustees and contributors to the Museum'. The meetings at which the portrait was discussed were chaired by Sir Arthur Palmer, a pastoralist and former premier; possibly he and Coxen may have had differences. A few weeks later, on 8 March, Elizabeth replied to the museum expressing her disappointment. She wrote: 'Many years ago, on reading an account of the Australian Museum, in which Alexander Macleay was mentioned as the Father or Founder of that institution, Mr Coxen expressed a hope that, that term might someday be applied to him in connection with the Queensland Museum'. She added, graciously, that she would accept the changed wording. The portrait is but one of the legacies Elizabeth Coxen has left Queensland.

Concluding Remarks

The contribution of Elizabeth Coxen to the understanding of Queensland natural history has been significantly underestimated, as has her role in supporting her husband Charles in his ornithological work and in founding and championing the Queensland Museum. One of Elizabeth's contemporaries, Henry Tryon, was to imply that it was her influence, rather than her husband's, which led the youthful Rowland Illidge to an interest in shells (Monteith & Mather 1986); Illidge, a fellow resident of Bulimba, later became one of Brisbane's leading naturalists of the early twentieth century (Tryon 1929). Elizabeth lived at a time when women


Charles Coxen C.M.Z.S.
Crown Lands Commissioner
Founder of the
Museum

Charles Coxen C.M.Z.S
Crown Lands Commissioner
Father of the
Museum

15/2/07
Omega Cottage
Bulimba Feb 15th
Dear Sir
I should like
one of the enclosed
to be engraved on a
brass plate and placed
under the Portrait
"Founder" of the Museum
but I think be better
than "Father"
Hoping you will carry out
my wishes
I remain
Yours truly
E F Coxen.

FIG. 10. Letter from Elizabeth Coxen to the Queensland Museum Trustees providing her two proposals for a plaque to be attached to the portrait of Charles Coxen. Sadly neither of these was used (Queensland Museum Library, archives, Letter 1087).

were not encouraged to partake in the sciences, let alone develop professional expertise or correspond with eminent scientists. Following her husband's premature death in 1876 she did not fade into the background as the widow of a prominent man, but sought recognition for his achievements and attempted to continue the scientific endeavours they had begun together. Her election as the first woman member of the Royal Society of Queensland in 1886 shows the esteem in which she was held within the learned community of her time. Elizabeth Coxen, as probably the first woman curator of any natural history museum in Australia, can be seen as a role model for today's museum women. But she did not seek such laurels. Rather, she would have believed in the public educational value of her work and in the importance of museums as key components of any progressive society.

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Pivotal temperature of Loggerhead sea turtles, *Caretta caretta*, from Dirk Hartog Island, Western Australia

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ABSTRACT

Investigating responses to different thermal conditions is important for understanding species with temperature-dependent sex determination, including loggerhead sea turtles. We determined the pivotal temperature for loggerhead turtles from Dirk Hartog Island, Western Australia, using constant temperatures in laboratory incubators. Eggs were transported from Dirk Hartog Island, Western Australia to Mon Repos, Queensland, at low temperatures to delay development and minimise movement induced mortality. The pivotal temperature for the Dirk Hartog Island loggerhead sea turtle rookery, is calculated to be 28.7 ± 0.4 °C (SD). The temperature is similar to the eastern Australian population of loggerheads, at the cooler end of a conservative global range. Incubators from 26.4 to 30.1 °C produced both male and female hatchlings, a range also consistent with eastern Australian loggerheads. Incubation periods ranged from 48 days at 31.6 °C to 77 days at 26.4 °C. The pivotal incubation duration to hatching is 63.3 ± 1.2 days (SD). This research indicates Dirk Hartog Island may be a predominantly male producing rookery with lower quantities of females expected.
❒ *Loggerhead sea turtle, Caretta caretta, Western Australia, pivotal temperature, temperature-dependent sex determination.*

Loggerhead sea turtles (*Caretta caretta* Linnaeus, 1758), like all species of sea turtles, have primary sex ratios determined by the incubation temperature during the middle third of development (Miller & Limpus 1981; Yntema & Mrosovsky 1980, 1982). The pivotal temperature is the calculated constant incubation temperature giving a 1:1 sex ratio of offspring (Dobbs *et al.* 2010; Mrosovsky 1988; Yntema & Mrosovsky 1982). Pivotal temperature is species-specific and even population-specific for sea turtles, ranging between breeding units of loggerhead turtles from 28.3 to 30 °C (Limpus *et al.* 1985; Chu *et al.* 2008; Yntema & Mrosovsky 1982; Mrosovsky 1988; LeBlanc *et al.* 2012; Marcovaldi *et al.* 1997; Mrosovsky *et al.* 2002; Fuller *et al.* 2013).

Pivotal temperature is an important biological parameter to quantify because when used in conjunction with nest temperatures, hatchling sex ratios under varying temperature regimes

can be predicted (Chu *et al.* 2008), and when included in population models for examining population performance it adds to capacity for considering management options (Chaloupka 2003). Pivotal temperature is part of the critical baseline data required for determining a turtle population's vulnerability to climate and other environmental change (Hamann *et al.* 2008; Hawkes *et al.* 2009; Poloczanska *et al.* 2009). Dirk Hartog Island in Western Australia currently supports the highest density of loggerhead sea turtle nesting in the world (Reinhold & Whiting 2014). The Western Australian loggerhead population is a genetically distinct stock (FitzSimmons & Limpus 2014), with a nesting distribution spanning 5° of latitude from Shark Bay to the Muiron Islands (Baldwin *et al.* 2003), with major densities of the population concentrated on the southern end of their range at Dirk Hartog Island in Shark Bay (Reinhold & Whiting 2014). Woolgar *et al.* (2013) estimated pivotal temperature for the stock using samples from Dirk Hartog Island and Gnaraloo Bay, but their study was limited by only finding mixed sexes at one temperature and low sample sizes at temperatures other than 29 °C, which would inflate the standard error of the estimate.

The work presented herein further refines the pivotal temperature of the Western Australian population, using a robust design with samples spread over a 5 °C incubation range.

METHODS

Egg collection and transport. Eggs were taken from turtles nesting on Turtle Bay on Dirk Hartog Island in Shark Bay (25°29′55″S, 112°59′16″E), Western Australia. Fifty eggs were collected from each of four clutches laid on the night of 11 December 2009. Eggs were preferentially taken from clutches laid closer to the sea and thus potentially vulnerable to tidal inundation. Immediately following laying, each sample of 50 eggs was packed into a Styrofoam esky with the minimum of rotation (Limpus *et al.* 1979) and transferred within one hour of oviposition to two portable refrigerators (two clutches per refrigerator) set at 9 °C on board a boat. The eggs were then transported by boat to Denham (three hours away). In the latter part of the sea voyage from Dirk Hartog Island to the mainland, it was found that one of the refrigerators had lost power supply from the plug being knocked out of the socket during the rough crossing and the eggs had increased in temperature, but the extent of this is not known exactly. This failure to maintain the low temperature in one of the refrigerators may have led to low successes in the two clutches in this refrigerator. The eggs were kept in the refrigerators until packed into a chilled esky (each clutch in individual soft eskies with a damp towel, surrounded by bubble wrap and freezer gel packs) for commercial flights from Denham to Perth, Perth to Brisbane, Brisbane to Bundaberg and then transported by road to the incubation laboratory at Mon Repos Conservation Park in Queensland. Temperatures inside the eskies were recorded using a data logger and uncalibrated digital ProSciTech maximum-minimum thermometers with external sensors, and showed variation between different parts of the esky during air transit ranging from 5 °C to 15 °C. At the end of the journey, the freezer gel packs were an icy slurry. The total time from oviposition until being placed in incubators in Queensland was 34 hours.

Incubation. Upon arrival at the incubation laboratory, each sample of 50 eggs from the same clutch was subdivided to batches of ten eggs and each batch was placed into one of five incubators at 27, 28, 29, 30 and 31 °C. Each group of 10 eggs were set in a single layer (to negate thermal effects of the incubating eggs) within a 2 L plastic container, with 1300 g of sterilised sand and 100 mL of distilled water (after Limpus *et al.* 1985). The damp sand just covered the top of the eggs (so that the tops of the eggs could easily be accessed for visual inspection), and plastic film food wrap covered the top of the container to allow gas exchange, but prevented moisture escaping and hence evaporative cooling. The respective containers of eggs from each of the four clutches were set together on the middle shelf of each of the incubators.

The 28, 29 and 30 °C incubators were Labec Laboratory Equipment Pty Ltd., and the 27 and 31 °C incubators were Qualtex Solidstat (Watson Victor Ltd). Temperatures had been allowed to stabilise before arrival of the eggs. All incubators were housed in a purpose-built air conditioned room with an "airlock" entrance. The temperature during incubation was measured using three methods: temperature data loggers, Nata-certified (National Association of Testing Authorities, Australia) thermometers and maximum-minimum thermometers. Data loggers allowed collection of the greatest amount of data but their accuracy was not as high as the Nata-certified thermometers, so these were used to create a calibration for the data loggers. Maximum-minimum thermometers were used to check for excessive fluctuations in temperatures.

Temperature data loggers (iButton DS1922L, Maxim Integrated Products) were placed both in the air and within the sand of each incubator. These are manufactured to have an accuracy of ± 0.5 °C. They were initialised to log temperature hourly with a precision of 0.0625 °C. The air temperature data logger for each incubator sat on top of the plastic film of one of the containers of eggs in the front half of the incubator. Each sand temperature data logger was located at egg depth in the same container. Although some studies have used a correction factor to take the temperature from inside the egg itself (Mrosovsky 1988; Marcovaldi *et al.* 1997; Mrosovsky *et al.* 2002), we used the ambient sand temperature, as this is the environmental parameter that acts on sex ratios in the field.

Nata-certified thermometers were positioned with a plastic brace in the middle front of each incubator (to enable reading with the inner glass door shut), with the bulb suspended in the air just below the middle shelf. The Nata curves supplied with each thermometer certified accuracy of -0.04 – -0.07 °C. It was assumed that the temperature of the sand inside the egg containers did not differ from the incubator air temperature. Nata-certified readings were taken twice daily.

Maximum-minimum thermometers were placed on the upper shelf of the incubators.

Sexual differentiation occurs during the middle third of embryonic development, but for practicality we used the mean temperature during the middle third time period of incubation. The shortest incubation duration was different for each incubator, so the middle third was calculated separately for each (27 °C: days 23-47; 28 °C: days 22-45; 29 °C: days 20-40; 30 °C: days 18-37; 31 °C: days 16-32). For the middle third of incubation, the hourly temperature readings of the air and sand data loggers were compared with the twice daily Nata-certified thermometer readings. A correction factor added to the sand temperature data loggers was the mean difference between all of the Nata-certified readings and the same-time data logger output over the middle third of shortest incubation duration for each incubator. The incubation temperatures presented throughout are the Nata-certified temperatures at which the incubators stabilised during the middle third of incubation duration. Using Nata-calibrated data loggers gave hourly temperature recordings with an estimated accuracy of ± 0.5 °C.

Sexing hatchlings. When the embryos had straightened out, internalised their yolk sacs and left the eggshell, they were weighed and measured. This is stage 31 ("incubation period complete"), of embryonic development, and the stage at which the term "hatchling" is used to refer to the hatched turtles (Miller, 1985). As there is no current reliable method to sex live hatchling turtles, hatchlings were euthanased with 0.3 mL of Valabarb given via an 18 gauge needle directly into the brain through the foramen magnum, resulting in a chemical and physical pithing effect on the brain. Gonads were cut out of each hatchling or unhatched embryo and sent to a commercial laboratory for sectioning, mounting and staining on microscope slides. Each sectioned gonad was examined for tissue of ovary or testis and photographed. Sex was determined for each gonad by independent examination of the micrographs by three of the authors (CJL, DJL, LR). A subsample of ten hatchlings was lodged

with each of the Western Australian Museum (registration numbers: 173019, 173020, 173021, 173022, 173023, 173024, 173025, 173026, 173027, 173028) and the Queensland Museum (registration numbers: QMJ92182, QMJ92183, QMJ92184, QMJ92185, QMJ92186, QMJ90950, QMJ92189, QMJ92190, QMJ92188, QMJ92187).

Calculating pivotal temperature and incubation duration. Pivotal temperature was calculated using the simple logistic equation, Y(Sex ratio)=100/(1+exp((-k*(X(Incubation Temperature)-x0)))), where k and x0 are fitted variables, with 95% confidence intervals estimated using Monte Carlo simulation using the predict *nls* function in R (R development core team 2016). Incubation duration was calculated as the time from being set in the incubators until turtles hatched and left their eggshell.

Ethics and permiting. This project was conducted under Regulation 17 Licence to take fauna for scientific purposes (number SF007142) and Regulation 18 Licence to export fauna interstate (number EA006170) issued by the (former) Western Australian Department of Environment and Conservation. Ethics approval was given by Queensland Animal Research (number DERM/2009/1009).

RESULTS

Temperature validation. The five incubators stabilised at 26.4, 27.4, 29.0, 30.1 and 31.6 °C (Nata-calibrated) during their respective middle thirds of incubation duration. The data loggers consistently read higher than the Nata-certified readings. In three of the incubators, the sand data loggers read higher than the air data loggers, and in two of the incubators the air data loggers read the highest. The average difference between the data loggers and the Nata-certified readings was + 0.9 °C (range + 0.3 – + 1.8 °C). All temperatures referred to throughout are Nata-calibrated.

Pivotal Temperature. Both sexes were produced within the lower ranges of temperatures investigated (26.4 °C to 30.1 °C), with the upper temperature of 31.6 °C producing exclusively female hatchlings (Fig. 1). The pivotal temperature was 28.7 ± 0.4 °C (SD). The transitional range of temperatures could not be calculated because we did not incubate at a temperature low enough to produce 100% males for all clutches.

There appeared to be clutch-specific differences in sex ratios at different temperatures (Fig. 2). Specifically, clutch WA77807 gave a higher ratio of females at the lower two incubation periods (26.4 and 27.4 °C) than the other clutches with all other clutches having no females at these temperatures (Fig. 2).

Neither hatched embryo SCL nor mass were significantly correlated with incubation temperature ($t_{(1,60)}$=1.44, P=0.15, see Table 1 for mean values) or sex (($t_{(1,60)}$= 1.36, P= 0.18)); female mean SCL= 3.95 mm (SD= 0.20, N= 36); male mean SCL= 4.02 mm (SD= 0.18, N= 26); female mean mass= 16.9 g (SD= 1.1, N= 36); male mean mass= 17.3 g (SD= 1.2, N=26).

Incubation duration. The pivotal incubation duration was 63.3 days (SD= 1.2), with shorter incubation durations producing more females and longer incubation durations producing more males (Fig. 3). At incubation durations of 55 days and less, only females were produced. Mixed sexes were produced from 56 days to 70 days.

Incubation duration was highly correlated with temperature (r= 0.96, P<0.001, Fig. 4). There were clutch-specific differences in incubation period, with the two clutches that incubated at 26.4 °C differing by seven days. It was the clutch with the shorter incubation period that produced the females at this temperature. At 27.4 °C incubation duration between clutches differed by only one day, at 29.0 °C all clutches hatched on the same day, at 30.1 °C hatching spanned two days between clutches, and hatching of the four clutches at 31.6 °C spanned four days (Table 1). All hatched turtles in each container of 10 from the same clutch reached stage 31 (Miller 1985) on the same day as each other, meaning there was no variation in incubation duration within clutches at the same temperature.

TABLE 1. Incubation success and sex ratio results for each incubation temperature, pooled for all four clutches.

Incubator temperature	26.4 °C	27.4 °C	29.0 °C	30.1 °C	31.6 °C
Incubation period - days (d)	70-77	67-68	60	55-57	48-52
Number of eggs incubated	40	40	40	40	40
hatched	13	16	12	13	17
unhatched	8	8	15	21	5
undeveloped	19	16	13	6	18
Hatch success	32.5%	40.0%	30.0%	32.5%	42.5%
Hatchling SCL (mean ± SD) mm	4.06 ± 0.20	4.03 ± 0.12	4.03 ± 0.18	3.91 ± 0.19	3.92 ± 0.21
Hatchling mass (mean ± SD) g	17.6 ± 1.3	17.2 ± 0.9	16.8 ± 0.8	16.6 ± 1.4	16.7 ± 1.0
Hatchling size sample size	13	16	12	13	17
Gonads sampled	14	24	18	28	20
not sexed	4	5	3	7	0
male	8	15	8	2	0
female	2	4	7	19	20
Sex ratio: % female	20.00	21.05	46.67	90.48	100.00

Hatching success. Hatching success was reasonable (mean = 56%) only for two of the clutches (64% hatching success for clutch WA77807 and 48% hatching success for clutch WA77813). The other two clutches had a poor hatch success (mean of 15%, comprising 22% from clutch WA41640 and 8% from clutch WA77815). This was associated with a severe fungal infestation that spread from dead eggs to adjacent incubating eggs resulting in death of a number of eggs mid-incubation. As a consequence of an overall low hatch success of 35.5%, the sex ratio results from all four clutches were pooled in Table 1. Individual-based differences were apparent and shown in Fig. 2 however, this may be biased by low sample size.

Identification of sexes. Gonads were able to be sexed from 85 of the eggs (62 out of the 71 hatchlings, and 23 out of the 57 unhatched embryos). Gonads were able to be differentiated from unhatched embryos as small as 28 mm straight carapace length (SCL).

DISCUSSION

Local and global context. The Dirk Hartog Island loggerhead population's pivotal temperature of 28.7 °C is similar to the 28.6/28.3 °C of eastern Australian loggerheads (Limpus *et al.* 1985; Chu *et al.* 2008). This pivotal temperature is also similar to Woolgar *et al.* (2013)'s 29.0 °C for Dirk Hartog Island and Gnaraloo Bay in Western Australia. With samples concentrated at 29 °C in the Woolgar *et al.* study, it was the only temperature at which mixed sexes were detected. The Woolgar *et al.* study also differed by using data loggers with a manufactured accuracy of ± 1 °C rather than Nata-calibrating temperature readings. The data loggers used for our study had a manufactured accuracy of ± 0.5 °C, and differed from the Nata-calibrated thermometers by an average of + 0.9 °C. These Australian studies combined show an overriding similarity in pivotal temperature for a species which has a discrete anti-tropical nesting range either side of the continent.

The 28.7 °C calculated here is towards the lower end of a globally conservative pivotal temperature band for loggerhead turtles,

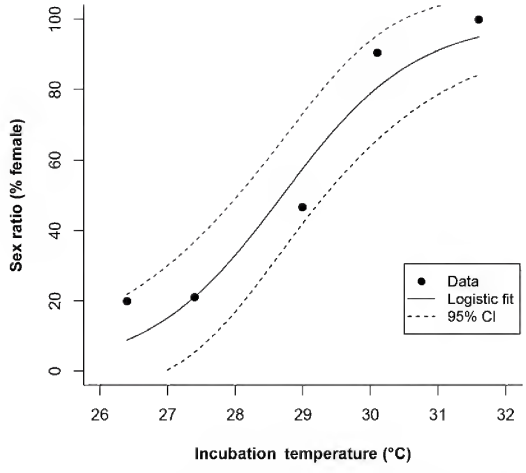

FIG. 1. Sex ratio of *Caretta caretta* hatchlings relative to constant incubation temperature, with logistic regression fit using the *nls* function in R with the logistic equation Y(Sex ratio) = 100/(1+exp((-k*(X(Incubation Temperature)-x0)))), where k and x0 are fitted variables. Results of eggs from four nesting females pooled. 95% confidence limits were calculated using Monte Carlo simulation using the predict *nls* function in R (R development core team 2016).

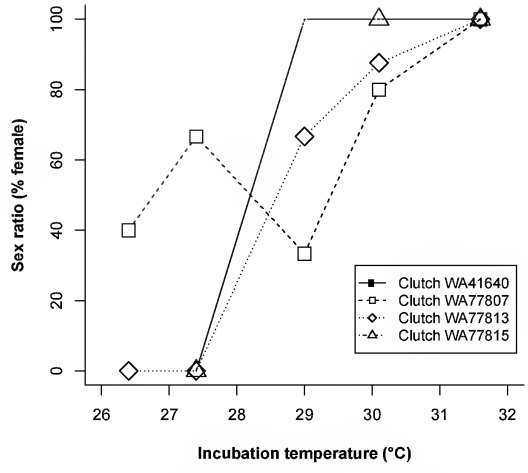

FIG. 2. Clutch-specific sex ratios of *Caretta caretta* hatchlings. Sample sizes for the clutches at 26.4, 27.4, 29.0, 30.1 and 31.6°C incubation temperatures respectively were NA, 3, 1, 5, 5 (Clutch WA41640); 5, 6, 8, 5, 4 (Clutch WA77807); 5, 8, 6, 8, 9 (Clutch WA77813); and NA, 2, NA, 3, 2 (Clutch WA77815).

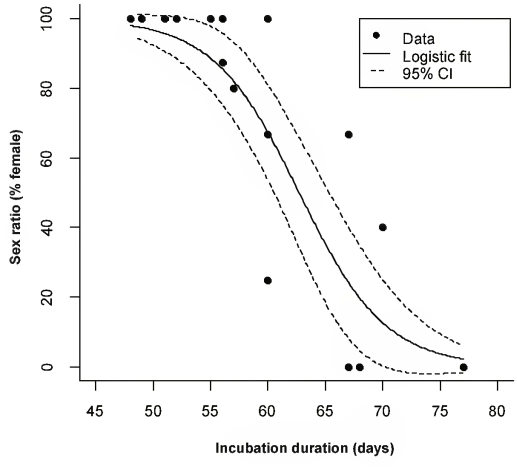

FIG. 3. Sex ratio of *Caretta caretta* hatchlings relative to incubation duration, with logistic regression fit using the *glm* package in R (R development core team 2016).

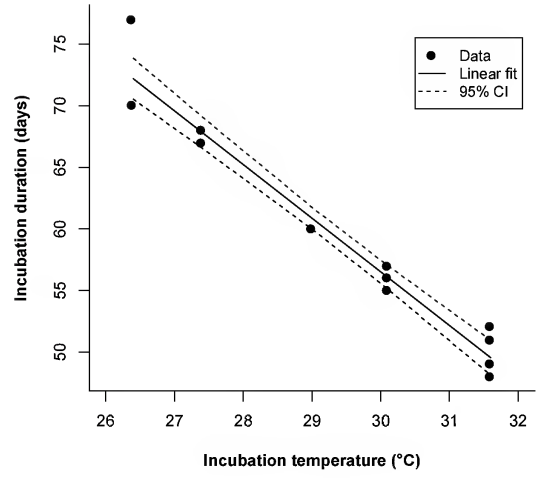

FIG. 4. Incubation duration in days from setting in incubators until hatched embryos left the eggshell, relative to incubation temperature. Solid lines show linear fit (incubation duration = -4.35* incubation temperature + 187.2); dashed lines show 95% confidence limits for linear fit.

differing by no more than a degree either side of 29 °C (Yntema & Mrosovsky 1982; Mrosovsky 1988; LeBlanc *et al.* 2012; Marcovaldi *et al.* 1997; Mrosovsky *et al.* 2002; Fuller *et al.* 2013).

Incubation duration. Pivotal incubation durations described within may be a useful field parameter to estimate the sex ratio production of nesting beaches. Marcovaldi *et al.* (1997) described a method for using pivotal incubation duration to estimate hatchling sex ratios. This method would enable clutch-specific identification of sex production in studies where incubation duration is recorded. To convert our measured incubation durations into incubation duration to emergence, which is used for in situ studies, the number of days it takes hatchlings to climb to the surface of the sand and emerge must be added. This has yet to be defined for Western Australian beaches, but can be estimated comparing the incubation duration and temperature correlations presented herein to incubation durations and temperatures measured for nests in situ. As Jribi *et al.* (2013) pointed out, though, this method may not be as accurate in the field as using pivotal temperature because the temperatures at the first and last thirds of incubation may confound the incubation duration. Field conditions in general mean rates of development may not occur consistently throughout incubation.

For loggerheads at the Dirk Hartog Island rookery, clutches which take from a week either side of 63 days to hatch are likely to have a mixed sex ratio. If clutches are consistently taking less than 56 days to hatch, they are likely to be producing 100% females.

The two-week span of incubation durations producing mixed sexes here is similar to that found on the east coast of the USA (Mrosovsky 1988), and approximately twice as broad as that estimated for loggerhead turtles in Brazil (Marcovaldi *et al.* 1997) and the Mediterranean (Mrosovsky *et al.* 2002; Fuller *et al.* 2013). It is, however, significantly less than the five-week span recorded by Limpus *et al.* (1985), but we did not incubate at a temperature that produced 100% males, so with a greater sample size, the mixed-sex incubation duration for Dirk Hartog Island may also span greater than two weeks. Individual clutch differences can contribute greatly to the spread of sex ratio vs incubation duration curves, and this should be kept in mind when using steep curves to infer sex ratios, as Godley *et al.* (2001) identified.

Transitional range of temperature (TRT). For the Dirk Hartog Island loggerheads, both males and females were produced over a range of 3.7 °C (this is likely to be greater if more clutches were incubated, and at lower temperatures). This is consistent with results from eastern Australian loggerhead turtles (Limpus *et al.* 1985), as well as loggerheads from the east coast of the USA (Girondot 1999). Even our coolest incubator, at 26.4 °C, produced some females. Males were still being produced at 30.1 °C, but very few males are expected to be produced if incubation temperatures exceed 31 °C. Woolgar *et al.* (2013) calculated a much narrower transitional range (0.7 °C) for loggerhead turtles at Dirk Hartog and Gnaraloo. The lower two temperatures for the Woolgar *et al.* study were similar to ours, but the samples of five eggs at each of these lower temperatures produced only male hatchlings.

Clutch-specific differences. Observed clutch-specific differences highlight the importance of using several different clutches when investigating temperature-dependent sex determination. The clutch from adult female WA77807 produced all of the females at the two lowest incubation temperatures, and without this we could have reported an artificially narrow transitional range of temperature and an artificially high pivotal temperature. The contribution of the clutch from this one nesting female increased the range of female-producing temperatures by 2.6 °C. Similar clutch-specific differences were also observed by Limpus *et al.* (1985), Mrosovsky (1988), Maxwell *et al.* (1988) and Wyneken & Lolavar (2015). Limpus *et al.*'s (1985) study on the Australian east coast loggerhead pivotal temperature had three out of four clutch samples incubated at 26 °C producing 100% males, yet one clutch sample produced three females. The same clutch also had a higher proportion of female hatchlings in the 27.5 °C

incubator. Mrosovsky (1988) found one clutch from Florida produced significantly more males at middle and feminising temperatures than the other clutch from the same location. Wyneken & Lolavar (2015) found eight out of nine Florida clutch samples incubated at 31.4 °C produced 100% females, yet one clutch sample produced a male. At feminising temperatures, it may be these individuals which increase their relative contribution to the gene pool by producing males when others cannot.

Hulin *et al.* (2009) highlighted the importance of variability between individuals, and of the proportion of mixed nests being correlated to sample size. Whether Australian and eastern USA loggerheads have greater genetic variability between individuals with a broader overall TRT than loggerheads from other parts of the world, or whether this is an artefact of sampling, is yet to be determined. If the difference is real, it would give such populations a better chance of evolving to a changing climate.

Hatching success. The relatively low hatching success of two of the clutches was most likely caused by movement-induced mortality and the spread of a fungal infection. We can only speculate at which point the movement-induced mortality occurred: the clutches in one of the refrigerators warmed up during the rough sea voyage from Dirk Hartog Island to the mainland; the sea voyage itself may have caused far more violent and prolonged movement than turtle eggs can withstand; eggs towards the top of the esky may have warmed up more than those near the thermometer probes – the outside temperature on the day of transit was 41 °C at Shark Bay Airport and 37 °C at Perth Airport, where the outside of the esky was hot to the touch when it was unloaded from the plane; the clutch of WA41640 dipped to 5° C within the esky, but other parts of this same clutch may have been at a lethal cooler temperature, especially as the maximum-minimum thermometers were uncalibrated; parts of the clutch that reached 15 °C in the esky may have been at an even higher temperature, but this was the clutch with the best hatch success, and the clutches with reasonable and poor hatch success alternated within the esky; eggs could have been starting to develop as they warmed up awaiting placement in the incubators. Although this reduced sample sizes, it is unlikely to compromise the experiment as there is no known sex-biased mortality rate for turtle embryos.

Eggs were not randomised within their containers within the incubator, but all clutches were incubated over all temperatures. This means that whether the observed clutch-specific differences were due to the container they were placed in, or inherent to that clutch is unknown. Poor hatching success was attributed to both movement induced mortality and also spread of fungal infection from the non-viable eggs. If the eggs from the two clutches with poor hatching success were placed in containers with viable eggs from the other two clutches, hatching success for all clutches may have been reduced through spread of fungal infection.

In situ nest conditions. Our study was designed to determine how sex ratios change with laboratory-controlled temperatures, but constant temperature may not be the only contributing factor. The environmental conditions that influence the sex ratios of in situ nests are still being described.

Wyneken & Lolavar (2015) found high nest moisture to produce a greater percentage of male loggerhead hatchlings in Florida, even at temperatures above the pivotal. This research means that even if the sand at Turtle Bay was to rise to strongly female-biased dry-sand temperatures, cyclone rainfall at critical times of incubation could not only cool the sand, but enable the production of males because of increased moisture content. Our results are from sand set with a water content of 7.7%, to standardise with Limpus *et al.* (1985), but sand moisture was not tested throughout incubation.

Conservation implications. Recorded temperatures at Dirk Hartog Island from Trocini (2013) indicate that Dirk Hartog Island may be a predominantly male-producing rookery, but produces a mix of males and females across all northern beaches. Trocini (2013) measured sand temperatures at 50 cm depth with data loggers

(temperature accuracy ± 0.5 °C) over five beaches at the rookery on Dirk Hartog Island during the 2007/08 season. The mean sand temperature for the middle third of incubation for Beach 1 was 28.3 °C ± 0.5 °C SD (n=4), for Beach 2 was 28.6 °C ± 0.4 °C (n=4), and for Beaches 3 and 4 were 29.1 °C ± 0.4 °C (n=4). Sand temperatures on Beach 5 were higher (n=5), but nests there were not monitored to correlate to the middle third period. These sand temperatures mean that at least for the 2007/08 season, all main nesting beaches along the northern end of Dirk Hartog Island were producing both male and female hatchlings. We borrowed some of these same iButton data loggers from S. Trocini for our laboratory study after her in situ research. When we Nata-calibrated these data loggers, temperatures had to be corrected down by an average of 0.9 °C. This means actual sand temperatures on Dirk Hartog Island may have been cooler than recorded by these data loggers, but still within a range that produces a mix of female and male hatchlings. Trocini (2013) gives in situ data for mean middle-third within-nest temperatures and incubation to emergence period by beach for 77 nests over four beaches over two seasons. Within-nest middle third incubation temperatures of about 28.5 °C had an incubation to emergence period of 63 days, and temperatures of 29.7 °C had an incubation to emergence period of about 59 days. The middle third of development can be kept at a constant temperature in an incubator, but in the field is subject to fluctuations, and in 2007/08 Cyclone Nicholas caused a cooling spike towards the end of this period. Trocini (2013) also found that the temperature inside nests was slightly higher and fluctuated less than sand temperatures at the same beach.

The increase in sand temperatures that Trocini (2013) found from west to east at this northern-facing rookery is likely a result of afternoon shading of the western-most beaches which are backed by 50 m-high limestone cliffs, flattening out towards Beach 5 in the east. The western end of Beach 1 supports a cooler pocket of sand backed by high cliffs to the west. Trocini (2013) also found that nests closer to the cliffs had lower temperatures than nests further out on the beach.

The sand at 50 cm depth on these beaches would have to rise by about 3 °C above 2007/08 temperatures to prevent males from being produced at that time of the season. Trocini's (2013) in situ nest data loggers were deployed mid-January, which means the middle third of incubation duration fell during February, which is the hottest month of the year. The 2007/08 season had a February mean maximum air temperature in Denham (72 km away) 0.4 °C below the mean (mean=32.0 °C), and a mean minimum temperature of 1.0 °C above the mean (mean=23.0 °C), for the 29 years from 1989 to 2017 (http://www.bom.gov.au/climate/data/). Clutches laid when the middle third fell earlier or later in the season would be even more likely to produce males. The temporal span of nesting is broad, with occasional turtle tracks being observed on Dirk Hartog Island throughout the year (R.I.T. Prince, pers. comm.).

Whereas the male-producing beaches are generally thought of as being at the cooler minor extremities of a population's nesting range (Marcovaldi *et al.* 1997; Mrosovsky 1988; Jribi & Bradai 2014), in the case of the Western Australian loggerheads, the cooler part of the range is also the major nesting site for this population.

In the absence of trees at Western Australian loggerhead rookeries, shading from the distinctive cliffs and the chance of cyclone rainfall could become important factors for the continuation of male hatchling production at Dirk Hartog Island in the advent of global warming.

Conclusions. This study provides an estimate of pivotal temperature with high accuracy for loggerhead turtles within the Western Australian stock. Pivotal temperature calculated herein and in situ temperature data collected by Trocini (2013) indicate that the rookery produces predominantly male turtles, with lesser numbers of female turtles also produced. The impact of potential thermal increases in sand temperature from global warming on sex ratios can now be quantified across a 5 °C temperature span.

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***Passeromyia indecora* causes hematophagous myiasis in captive-bred domestic pigeon (*Columba livia domestica*) squabs.**

Larval instars of the native dipteran *Passeromyia indecora* (Walker) (Diptera: Muscidae) induce subcutaneous hematophagous myiasis in nestling birds (Couri & Carvalho 2003). Infestations are often highly pathogenic, leading to host mortality or reductions in growth (Skidmore 1985; Poiani 1993). Associations between this generalist obligate parasite and several avian hosts have been documented (Pont 1974), but we report the first case from a captive-bred introduced species, the common pigeon, *Columba livia domestica* Gmelin. Incomplete larval taxonomy make the identification of *Passeromyia* Rodhain and Villeneuve challenging as current morphological descriptions (Skidmore 1985) do not allow for unequivocal species discrimination. The use of DNA barcoding provides an alternative diagnostic tool in the absence of a morphological-based approach and when rearing larvae is not feasible.

In mid spring 2015, myiasis in a two-day old, captive-bred pigeon squab was reported from a property in the dry tropics region of Bluewater, Queensland (19°09'37.7"S 146°33'57.7"E). A cluster of tiny maggots were collected from inside a puncture wound on its back approximately 2 mm in diameter and from inside both ears. Beneath the infested areas, the skin was swollen and abraded. Over the ensuing fortnight, maggots at various developmental stages were removed daily from the same individual and an additional infested squab subcutaneously at the base of new growing wing feathers. Several of the specimens collected from both squabs were submitted in ethanol to the laboratory for identification. Voucher specimens were lodged at the Queensland Museum (one first instar larva T207468, one third instar larva T207469).

Larvae collected from the two day old pigeon squab were identified as first instars of *Passeromyia* based on a feature unique to the genus at this life-stage: six long perispiracular filaments located dorsally (Skidmore, 1985). Larvae obtained from the same bird and a second squab over subsequent days were considerably larger and more mature. These were identified as third instar larvae due to their size (10 mm – 15 mm) and cephaloskeletal structure (Skidmore 1985). However, establishing a species-level identification of the specimens was not possible using the incomplete taxonomic descriptions and figures published by Skidmore (1985). While the larval life-history (sub-cutaneous blood-feeders) and geographic location (Queensland) from which our specimens were collected were indicative of *P. indecora*, it was important to establish a firm species identification. Molecular confirmation was therefore sought through the use of DNA barcoding.

DNA was isolated from one of the unidentified third instar larvae and from an adult fly of *Passeromyia longicornis* (Macquart) reared from a larva collected from a forty-spotted pardalote (*Pardalotus quadragintus* Gould) nestling on North Bruny Island, Tasmania (43°05'44.0"S 147°21'31.0"E) in October 2014. We performed standard PCR and sequencing using TY-J-1460 and C1-N-2191 primers according to Grzywacz *et al.* (2017) to obtain standard barcode fragments of mitochondrial cytochrome c oxidase subunit I. DNA sequences were blasted against those deposited in GenBank. The sequence we obtained for the unidentified larva (GenBank accession no. KY937945) was 100% identical with the sequence referring to *Passeromyia indecora* (GenBank accession no. KJ510635) (Kutty *et al.* 2014) and differed by more than 5% from the sequence we obtained for *P. longicornis* (GenBank accession no. KY937944). On this basis, we concluded that the material collected from the pigeon squabs were immature stages of *P. indecora*.

In Australia to date, *Passeromyia*-induced myiasis has been reported almost exclusively from wild native hosts (Pont 1974; Armstrong & Pyke 1991; Poiani 1993; Edworthy 2016, but see Green & Munday 1971). Here, we report the first infestation from an introduced host in a domestic setting, and provide the first record, to our knowledge, of a species of *Passeromyia* infesting a member of the host order Columbiformes. The prevalence of this group of highly adaptive, generalist parasites is not well known due to the scarcity of recent published accounts (Armstrong & Pyke 1991; Poiani 1993; Levot 2008; Edworthy 2016). For *P. indecora*, few data have accrued since early collections referenced in Pont's (1974) revision of the genus, although historical records show a widespread distribution across all states in Australia except Tasmania (Pont 1974). Our case is the first to be documented in Queensland for several decades and extends the host range for this dipteran parasite. The pathogenic effects of myiasis in these captive-bred pigeons were undetermined as both squabs were killed by an unrelated cause immediately after the collection of larvae. No further reports of myiasis were made following the outbreak and the implementation of control measures (e.g. burning of nest material).

From a biosecurity standpoint, the accurate and timely diagnosis of myiatic agents is important to ensure effective on-farm treatment and exclude exotic organisms. Despite the fact *Passeromyia* consists of only five species (two of which occur on mainland Australia and one in Tasmania), the larval taxonomy remains incomplete and inadequate for high-level diagnostics. Descriptions of the first instar stage are particularly deficient with only one of five species, *P. heterochaeta* (Villeneuve) documented (Skidmore 1985). Immature stage descriptions of *P. indecora* are limited to the second instar, derived from two specimens collected from a red-capped robin, *Petroica goodenovii* Vigors & Horsfield in NSW and some features of the third instar cephaloskeleton derived from seven puparia collected from a fairy martin, *Petrochelidon ariel* (Gould) in NSW (Skidmore 1985). The morphology of adult and pupal stages of *Passeromyia* are more comprehensive (Skidmore 1985), but rearing larvae is not always practical. DNA sequence data are available for *P. indecora* (Kutty *et al.* 2014) but molecular data for the genus are otherwise lacking. Expanding the taxonomy of immature stages of Australia's sole genus of avian myiasis-causing flies would greatly increase diagnostic capacity during outbreaks among captive-bred or production birds. An expanded molecular database would also provide an additional resource for diagnosticians.

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The coral killing sponge *Terpios hoshinota* in Kimbe Bay, Papua New Guinea.

The coral killing cyanobacteriosponge *Terpios hoshinota* was initially described from Japan and Guam following an outbreak in 1984 (Rützler & Muzik 1993), but since then has expanded its range to other areas, including Taiwan (Liao *et al.* 2007), Australia (Fuji *et al.* 2011), Indonesia (de Voogd *et al.* 2013, van der Ent *et al.* 2016), Malaysia (Hoeksema *et al.* 2014), the Maldives (Montano *et al.* 2015) and Mauritius (Elliot *et al.* 2016). *Terpios hoshinota* encrusts a wide range of coral species and outbreaks cause mortality over large areas of reef (Rützler & Muzik 1993). Outbreaks may be devastating on local scales, but reefs can recover, even when the sponge co-exists in the area for 25 years (Reimer *et al.* 2010) and of course outbreaks can reoccur (Yomogida *et al.* 2017)

During recent sponge biodiversity and coral health surveys in Kimbe Bay, Papua New Guinea, the dark gray encrusting sponge was observed overgrowing live corals in the genera *Acropora* (branching and plate species), *Montipora* (branching and encrusting species), *Goniastrea, Leptoria,* and *Pocillopora* on the reef flat at Kimbe Island (Figure 1). When preserved, the sponge tinted ethanol a green colour, indicating the presence of cyanobacteria. Examination of the sponge spicules under light and scanning electron microscopes confirmed the distinctive spicule tylostyles to be those of *T. hoshinota*. The specimen of *T. hoshinota* collected from Kimbe Bay was compared to specimens of *T. hoshinota* previously collected from Japan and Australia (Fuji *et al.* 2011). This particular specimen from Kimbe Bay (QM G336069), along with another specimen from Australia (QM G331911) and the specimen from Japan (QM G331910), show a larger maximum tylostyle width than the original description (Rützler & Muzik 1993) see Table 1. The head of the tylostyles of these specimens (Figure 2) match those of *T. hoshinota* which have characteristic lobes that separate it from other *Terpios* species with a similar colouration i.e. *T. granulosa* Bergquist, 1967, *T. viridis* Keller, 1891, *T. fugax* Duchassaing & Michelotti, 1864 and *T. manglaris* Rützler & Smith, 1993.

This is the first record of *T. hoshinota* from Papua New Guinea, extending its range into the South Pacific Ocean. Kimbe Bay has previously been searched by the authors for sponge biodiversity in 2007 and corals from 1997 till 2016 with no previous signs of corals affected by *T. hoshinota*. In addition, the authors have been conducting sponge biodiversity surveys in other parts of Papua New Guinea, including Milne Bay (2005), South Papua New Guinea Barrier Reef (1996), and Vanuatu (1996, 1997, 2008), and *T. hoshinota* has never been recorded before, further strengthening the hypothesis that this is a recent introduction into Kimbe Bay. The influence of disturbances such as coral bleaching, disease and naturally-occurring predators such as the crown-of-thorns starfish, *Acanthaster planci* (Linnaeus 1758) on coral abundance is well documented, but the current and potential future impact of invasive species

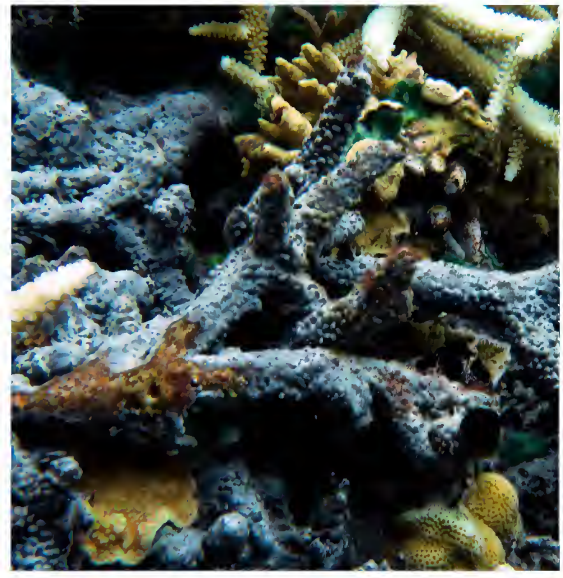

FIG. 1. *Terpios hoshinota* overgrowing live corals at Kimbe Island, Kimbe Bay, Papua New Guinea on the 19th of November 2016 (5.20328°S, 150.3803°E).

FIG. 2. Tylostyle heads of *Terpios hoshinota* QM G336069

TABLE 1. Tylostyle measurements (minimum, average, maximum) of specimens of *Terpios hoshinota* (in µm).

Specimen, location	n	Total Length	Maximum width	Neck Width	Head Width	Head Length
Description	?	160-290	2.0-4.0	1.5-3.5	3.5-7.0	4.0-7.5
USNM43144, Japan	?	180-252-290	3.0-3.5-4.0	2.0-2.7-3.0	5.5-6.1-7.0	4.5-5.2-6.0
G331910, Japan	25	175-244-283	2.2-5.2-7.0	2.4-3.7-4.9	3.2-6.4-8.9	3.7-6.6-8.2
G331911, Australia	25	171-222-251	2.2-3.2-4.2	1.2-2.2-3.2	3.9-5.8-8.9	2.7-4.6-5.9
G336069, PNG	45	152-216-329	2.2-6.4-10.7	2.5-4.0-5.9	4.1-6.8-9.5	3.9-4.0-9.2

on Indo-Pacific coral reefs has received little attention. Our observations highlight the potential significance of invasive species as an agent of coral decline warranting greater attention.

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A Queensland Government Project
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Range extension for the leaf-tailed gecko *Phyllurus gulbaru* in North Queensland.

The Gulbaru gecko (*Phyllurus gulbaru*, Carphodactylidae: Hoskin, Couper & Schneider, 2003) is a leaf-tailed gecko currently known only from the Paluma Range in the southern edge of the Wet Tropics north-west of Townsville, Queensland (Hoskin, Couper & Schneider 2003). It is restricted to two sub-populations, separated by unsuitable habitat, which cover a total area of 21 km^2 with an actual range of approximately 14 km^2 (Hoskin *et al.* 2003). Listed as critically endangered (International Union for Conservation of Nature [IUCN], 2010; *Environment Protection and Biodiversity Conservation Act* 2015), most of its rainforest habitat is currently unprotected. In this short note we report a range extension of *Phyllurus gulbaru*.

On 8th October 2015, a Gulbaru gecko was sighted serendipitously during a spotlighting survey at Hervey's Range (-19.4°, 146.5°), on the edge of the Einasleigh Uplands, north-west of Townsville, more than 5 km from Patterson's Gorge in the Paluma Range. The gecko was found on the underside of a large boulder which formed the ceiling of a cave within piled boulders and rocks. A further two specimens were located within approximately twenty meters of the first gecko, in similar boulder-strewn habitat. The geckos were photographed and identified using the following characters, according to the key to *Phyllurus* in Wilson (2005): tail cylindrical; rostral scale partly divided; 8 pale bands on original tail (Fig.1).

The boulders in this dry rainforest habitat are large and stacked to form complex chambers and crevices. These boulders retain moisture better than the surrounding habitat, supporting an array of flora and fauna absent from the grassland and dry woodland across much of Hervey's Range.

The occurrence of *P. gulbaru* population represents a significant south-easterly extension for this species. It is presently unclear whether this discovery represents a completely separate population. With a road and seemingly unsuitable habitat between the Patterson's Gorge and Hervey's range populations, genetic analysis would be valuable in determining the level of divergence between the two populations. A large threat to *P. gulbaru* is the attention of poachers. Geckos are highly coveted among herpetoculturists and are often targeted by poachers (Nelson 2016). This is especially true of Australian leaf-tailed and broad-tailed geckos which are part of Australia's only entirely endemic reptile Family, and which inhabit very specific and limited ranges making them easy to find once their habitat has been accessed. The encouraging discovery of this population of *P. gulbaru* should therefore not undermine the value of protecting all existing populations, and thus our data depicting their exact location has not been included here.

FIG. 1. *Phyllurus gulbaru*

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A Queensland Government Project
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A redescription of *Lerista karlschmidti* (Marx & Hosmer, 1959) (Reptilia: Scincidae) from the Northern Territory and removal of this species from the Queensland faunal list by rejecting its type locality

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ABSTRACT

The current species concept for *Lerista karlschmidti* encompasses two widely disjunct populations, one in Queensland and the other in the Northern Territory. The two populations cannot be differentiated morphologically and genetic analysis is currently not possible since the original Queensland specimens (the type series) are likely to be formalin-fixed. The species has not been found in Queensland since its description, despite targeted searches by competent field herpetologists. Herein, we re-evaluate the collection data associated with the type specimens and also assess aspects of head scalation that are almost unique to this species. We conclude that *L. karlschmidti* is an endemic Northern Territory species, that the type locality of Woodstock, Queensland, is in error and that the species should be removed from the Queensland faunal list.
❒ *Lerista, Queensland, L. karlschmidti, Northern Territory, species.*

Lerista karlschmidti (= *Rhodona karlschmidti* Marx and Hosmer, 1959) was described from three specimens purportedly collected from Woodstock in north-eastern Queensland (19° 36′ S 146° 50′ E). It has not been seen in Queensland since, but populations currently assigned to this species also occur in the Northern Territory (see Figure 1).

In a recent review, we explored the history of the Queensland specimens and examined and compared the type series with specimens from the Northern Territory (see Couper & Amey 2009). We found no reason to doubt the collection data associated with the type series as it was supported by interviews with the late William (Bill) Hosmer (co-author of the type description) and Alex Johnson, the collector's son. Further, we found the type series to be composite with one paratype (FMNH17741) assignable to *L. cinerea* Greer, McDonald & Lawrie, 1983 (cited as *L.* cf. *storri* Greer. McDonald & Lawrie, 1983, in Couper & Amey, 2009; see Couper *et al.* 2016), a narrowly endemic Queensland species occurring in close proximity to Woodstock. Despite these facts supporting a Woodstock origin for the remaining two specimens, the possibility that a transcription error or some other problem occurred with this material cannot be excluded. This would explain why repeated attempts to find this species in Queensland have failed. The most recent of these was conducted in association with a three year Australian Biological Resources Study grant (Australian Government Department

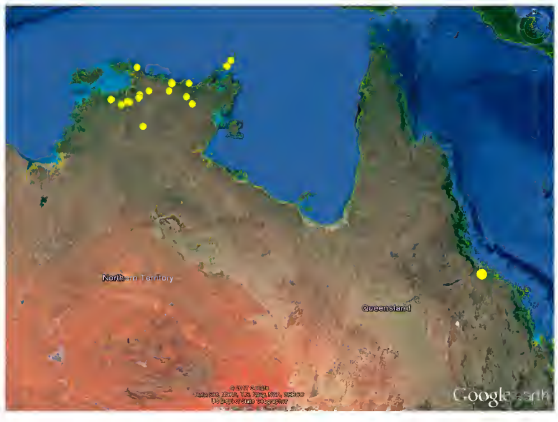

FIG 1. Map showing the known distribution of *Lerista karlschmidti* in the Northern Territory (yellow circles) and the purported type locality of Woodstock, Queensland (larger circle).

of the Environment and Energy) to survey *Lerista* species found in vine thicket communities in north Queensland (Couper *et al.* 2016).

Consequently, it is now timely to re-examine the question of a Queensland origin for the type specimens. In order to carry this out, one must consider the data associated with the type series and combine this with the information obtained from interviews with Bill Hosmer and Alex Johnson. The morphological distinctiveness of the species is also an important consideration. As the type material is likely to be formalin-fixed, a genetic comparison of it with the Northern Territory population is unfortunately not currently a feasible option.

The type data, as reported by Marx and Hosmer (1959), was previously taken on face value. However, the collection dates associated with each of the three specimens provide a useful clue when considered in conjunction with Bill Hosmer's recollection of being present when a specimen was found in Arnold Johnson's garden within the town of Woodstock (Couper & Amey 2009). The holotype (FNMH97957) and a conspecific paratype (FNMH97958) were both collected in 1952. The other paratype (FMNH97741) was collected in 1954. It is this latter specimen that is now referable to *L. cinerea* (see Couper *et al.* 2016), a species which is narrowly endemic to the Charters Towers region of north-east Queensland. It seems likely that this is the specimen captured in Arnold Johnson's garden. Additionally, there are two characters seen in the 1952 specimens and the Northern Territory *L. karlschmidti* that are comparatively rare in other *Lerista* species: the fusion of the second loreal with the prefrontal (observed in 9 of the 93 described species) and the loss of supraciliaries (observed in 8 of the 93 species). To find both states in a single species is rare indeed (3 of the 93 species, the other two being *Lerista labialis* Storr, 1971, widely distributed in Australia, including in far-western Queensland, and *Lerista simillima* Storr, 1984 from the south Kimberley region of Western Australia). It should be noted that some of these values were derived from species descriptions in the literature rather than from direct examination of specimens. Further, the values presented may not be absolute as there are inconsistencies in the terminology used by different researchers to describe head scalation. Nonetheless, they provide a measure of the rarity of these characters within the genus. For two widely disjunct populations, already convergent in all other characters measured, the occurrence of this rare combination of character states seems improbable, to say the least. In a previous publication (Couper & Amey 2009) we suggested that the Northern Territory and Queensland *L. karlschmidti* populations were unlikely to be conspecific. However, on reviewing the occurrence of these scale characters across all *Lerista* species, we now consider it equally unlikely that these specimens represent two different, yet highly convergent, populations.

In the absence of any Queensland specimens of *Lerista karlschmidti* being recorded in the 65 years since it was first described, despite considerable search effort, it is our belief that *L. karlschmidti* should now be regarded as an endemic Northern Territory species. Maintaining *L. karlschmidti* as a species with two widely disjunct populations fails to recognise the high levels of endemicity and low vagility seen in these lizards (Amey & Edwards 2017). Also, it is a glaring anomaly if one considers the distributions of other *Lerista* spp. (93

species). Upon considering the above points, we believe there are adequate grounds for removing *L. karlschmidti* from the Queensland faunal list. It is likely that Bill Hosmer did witness the collection of FMNH97741 from a garden in Woodstock in 1954 but it does not follow that the two 1952 specimens he received from Arnold Johnson were necessarily from the same locality. The Woodstock locality given for these specimens (FNMH97957 and FNMH97958) probably stems from a failure by Marx and Hosmer to recognise them as different from the Queensland specimen. In overall morphology *L. karlschmidti* is generally similar to that of *L. cinerea*, with only finer details of head scalation separating the two species. By considering all three specimens as conspecific, it made sense to these authors that that they all came from Woodstock. At the time, neither the huge diversity within *Lerista*, nor the subtlety of the characters delineating the species, could be conceived. There were only 25 recognised species now assignable to *Lerista* described, with only seven of these occurring in Queensland. In 1963, things remained much the same with Worrell, in his classic work Reptiles of Australia (Worrell 1963), recognising only 24 species and one subspecies (all contained within *Ablepharus* and *Rhodona*). That Arnold Johnson had not visited the Northern Territory prior to the collection of the type series by no means precludes the possibility that they were given to him by a third party who had.

Herein, we redescribe *L. karlschmidti* from a larger series of specimens and restrict this species to the Northern Territory.

MATERIALS AND METHODS

Morphology. All body measurements were taken using Mitutoyo electronic callipers (± 0.01 mm). Scales were counted on the right side only of specimens examined. The total number of enlarged nuchals is given, rather than the number of pairs. Only original tails (assessed by eye) were included in the morphometric analysis. Abbreviations and definitions of body measurements are detailed in Table 1. Preocular is here defined as the scale anterior to the eye margin contacting a loreal and the second supralabial; presubocular is the scale below the preocular, contacting the eye margin and the second and third supralabials; postoculars are the scales at the posterior margin of the eye and lying between the pretemporal and postsubocular and contacting the dorsal edge of the fourth supralabial; postsuboculars contact the postocular and the third and fourth supralabials; the pretemporal contacts the primary temporal, the parietal and the last supraocular; paravertebral count is the number of scales along the dorsum between the parietals and the posterior edge of the hindlimb, including any enlarged nuchals; supradigitals are the enlarged scales along the dorsal margin of the digit from the claw to the join with the pes. For the colour pattern description, dorsal row one refers to the paravertebrals. All other definitions follow Lillywhite (2008). Where ranges are given, they are followed by the mean ± the standard deviation.

Abbreviations for measurements used and their definitions.

EE Eye–ear (distance from posterior margin of eye to anterior margin of ear).

FN Frontonasal length (anterior point between nasals to posterior margin bordering rostral as a percentage of its width).

HL Head length (tip of snout to posterior margin of parietals)

HW Head width (widest point).

IW Maximum interparietal width as a percentage of its length.

L2 Hindlimb length (groin to tip of claw).

MV Midventral scale width (widest point of a ventral scale approximately midbody) as a percentage of paravertebral scale width (widest point of a dorsal scale approximately midbody).

MW Midbody width (width of body measured at approximately midpoint).

NaL Naris length (as a percentage of nasal scale length).

NC Nasal contact (length of contact between

FIG 2. The holotype of *Rhodona karlschmidti*, FMNH 97957.

two nasal scales as a percentage of their length).

PL Postmental length as a percentage of its width.

E Supralabial–ear (distance from posterior edge of last supralabial to anterior margin of ear).

SVL Snout–vent length.

TL Tail length (vent to tip).

SYSTEMATICS

Lerista karlschmidti (Marx & Hosmer, 1959)

Rhodona karlschmidti Marx & Hosmer, 1959
Figs 2 & 3

Diagnosis. *Lerista karlschmidti* can be distinguished from all other Lerista by the combination of monostylar hindlimbs, two loreal scales, no forelimbs, no prefrontals and no supraciliaries.

Etymology. Named by Marx & Hosmer (1959) for Karl Patterson Schmidt (1897–1957), a prominent herpetologist based at the Field Museum of Natural History, Chicago.

Type Locality. "…collected at Woodstock, about 23 miles south of Townsville, north Queensland, Australia…" (from Marx & Hosmer, 1959). For reasons outlined in the present account, this locality is concluded to be erroneous.

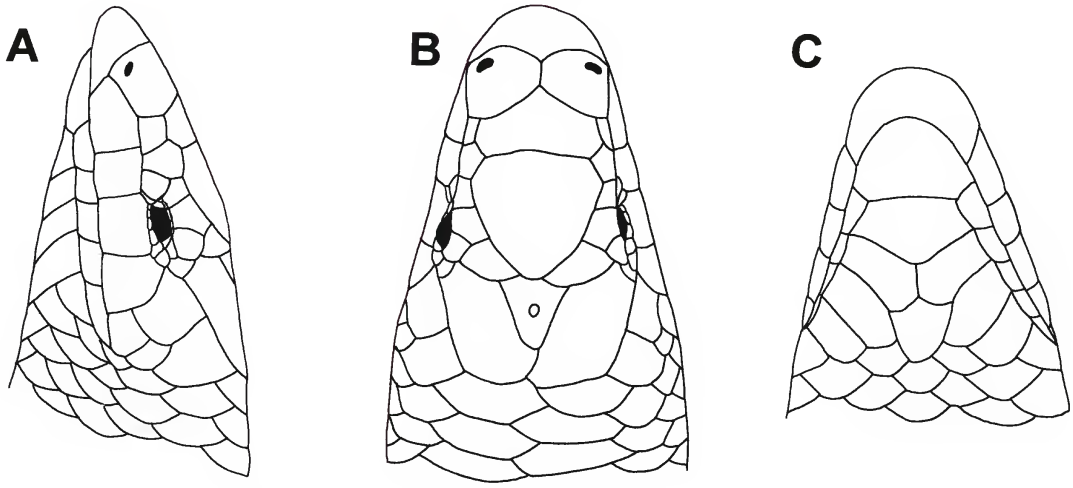

FIG 3. Scale arrangement of *Lerista karlschmidti* AMR88582, **A**, lateral view; **B**, dorsal view; **C**, ventral view.

Material examined. Abbreviations: AM = Australian Museum, Sydney, FMNH = Field Museum of Natural History, Chicago, NT = Northern Territory, NTM = Northern Territory Museum and Art Gallery, Darwin, QM = Queensland Museum, Brisbane. All coordinates use the datum GDA94.

Type material. FMNH97957 (Woodstock, 36 km S of Townsville, NEQ, 19° 36′ S 146° 50′ E [in error]; holotype), FMNH97958 (Woodstock, 36 km S of Townsville, NEQ, 19° 36′ S 146° 50′ E [in error]; paratype). The paratype believed to have been collected from Woodstock, Queensland (FMNH97741), and herein assigned to *L. cinerea*, is excluded from the material examined. This specimen is discussed and described in Couper & Amey (2009).

Other material examined. AMR88582 (Jabiluka Project Area, NT, 12° 33′ S 132° 55′ E, 8/08/1979), AMR88895 (Jabiluka Project Area, NT, 12° 33′ S 132° 55′ E, 17/09/1979), AMR97301 (Island Billabong, Jabiluka Project Area, NT, 12° 34′ S 132° 53′ E, 19/03/1981), NTMR 20995. Goyder River area, Arnhem Land, NT, 12° 38′ S 134° 49′ E, 05/08/1990, NTMR6178 (Goyder River Crossing, Arnhem Land, NT, 12° 56′ S 135° 02′ E, 29/08/1978), NTMR10963 (South Alligator River Ranger Station, NT, 12° 41′ S 132° 27′ E, 16/09/1977), NTMR12426 (East Alligator River, Rangers Camp, NT, 12° 26′ S 132° 57′ E, 28/05/1983), NTMR12560 (Milingimbi Settlement, NT, 12° 06′ 30″ S 134° 55′ E, 24/07/1984), NTMR12608 (Nabarlek, NT, 12° 19′ S 133° 19′ E, Oct, 1982), NTMR13884 (Nourlangie Rock, Kakadu National Park, NT, 12° 43′ S 132° 33′ E), NTMR16176 (Liverpool River Crossing, Arnhem Land, NT, 12° 22′ S 134° 07′ E, 18/07/1989), NTMR18481–18483 (Opium Creek Station, NT, 12° 33′ S 131° 47′ E, 16/02/1997), NTMR19012 (Malay Bay, Cape Cockburn, NT, 11° 21′ S 132° 52′ E, 19/06/1993), NTMR19044 (Guluwuru Island, NT,11° 30′ 00″ S 136° 26′ 12″ E, 28/07/1993), NTMR19054 (Wessel Islands, NT, 11° 29′ 18″ S 136° 25′ 48″ E, 27/07/1993), NTMR19062 (Guluwuru Island, NT, 11° 30′ S 136° 26′ 12″ E, 27/07/1993), NTMR19143 (Red Point, Marchinbar Island, NT, 11° 16′ 18″ S 136° 35′ 54″ E, 13/07/1993), NTMR20367 (Jabiluka Project Area, NT 12° 33′ 132° 55′ E, 20/06/1992), NTMR20996 (Goyder River Area, Arnhem Land, NT, 12° 38′ S 134° 49′ E, 5/08/1990), NTMR21521 (Jabiluka Project Area, NT, 12° 33′ 30″ S 132° 55′ 00″ E, 26/05/1992), NTMR22668 (Katherine River, Sleisbeck Area, NT, 13° 41′ 31″ S 133° 02′ 22″ E, 7/07/1996), NTMR24278 (West Alligator River, 3.3 km E, Arnhem Highway, NT, 12° 47′ 08″ S 132° 12′ 11″ E, 8/12/1998), QMJ82492–82495 (Maningrida, NT, 12° 2′ 33″ S 134° 14′ E, Aug, 2005), QMJ84188 (Maningrida airstrip, NT, 12° 05′ 42″ S 134° 14′ 16″ E, 8/8/2006).

Description. SVL = 41.8–70.4 mm (n = 29, 60 ± 7 mm), HL = 7–10% SVL (n = 29, 8 ± 1%), HW = 56–71% HL (n = 28, 66 ± 4%), SE = 20–32% HL (n = 26, 25 ± 3%), eyelid free, EE = 47–56% HL (n = 26, 51 ± 2%), ear minute, MW 5–8% SVL (n = 23, 6 ± 1%), L2 = 2–6% SVL (n = 29, 4 ± 1%), TL = 85–92% SVL (n = 2). Hindlimb usually with 1 clawed toe (n = 19) or reduced to stump (n = 10).

Midbody scale rows 16–20 (n = 29, mode = 16), NC = 17–48% (n = 29, 33 ± 7%), NaL = 13–26% (n = 26, 20 ± 3%), FN = 39–62% (n = 29, 54 ± 6%), three supraoculars, supraciliaries absent. Frontal contacts interparietal, frontoparietal, first and second supraoculars, 2nd loreal and frontonasal. Frontoparietals free, IW = 77–143% (96 ± 14%), two loreals, preocular single, presubocular single, 2–5 palpebrals (n = 26, mode = 4), postoculars 1–2 (n = 29, mode = 2), postsuboculars 1–2 (n = 29, mode = 2), five supralabials, third supralabial entering eye, postsupralabial single, usually five infralabials (6 in QMJ84188), usually two infralabials contacting postmental (one in NTMR18481, 19044, 19054, 19062, 20367, 1 and 2 in NTMR24278), one pretemporal, primary temporal contacts fourth and fifth supralabials, pretemporal, parietal and secondary temporals (also contacts postocular in 50% of specimens examined, n = 12), PL = 43–72% (n = 29, 58 ± 7%), three rows of enlarged chin shields, 2–6 nuchals (n = 29, mode = 3), 93–110 paravertebrals (n = 29, mode = 104), MV = 61–93% (n = 22, 77 ± 9%), 2–4 enlarged preanals (n = 26, mode = 2); hindlimb 2–8 body scales in length (n = 25, mode = 6), 3–5 subdigital lamellae under the longest toe (n = 18, mode = 3), 2–4 supradigitals on longest toe (n = 18, mode = 3), 82–86 subcaudals (n = 2).

Colour pattern. Tan to pale brown above, each scale with fine darker speckling and bearing a dark brown medial streak; strongest on scale rows one to four. In most specimens these form eight prominent, broken or continuous longitudinal stripes, which are sometimes widest on scale rows three and four. The stripes become increasing broken and obscure on the mid to lower flanks but in some individuals longitudinally aligned rows of spots are still evident on the ventral surface. There is no sharp demarcation between dorsal and ventral surfaces. Body stripes extend to original tail and become more obscure distally but are lost on regrown tails which have a more speckled

appearance. A sudden break in pattern clearly defines the point of tail loss. Ventral surfaces off-white, immaculate or with faint speckling or some indication of longitudinally aligned streaks. Underside of original tail also streaked. Dorsal head shields with irregular dark mottling. A smudge of darker pigment present on side of face, encompassing the nasal and loreals and extending through the eye to the temporal scales. Infralabials and chin shields diffusely speckled with darker pigment.

Distribution. (See Figure 1) This species is confined to the central and north-eastern parts of Arnhem Land in the Northern Territory (Horner 1992; Atlas of Living Australia (*http://www.ala.org.au* accessed 11 Aug, 2017).

Habitat. A fossorial species found in sandy substrates in tropical woodlands (Horner 1992; Atlas of Living Australia (*http://www.ala.org.au*, accessed 11 Aug, 2017).

Comparison with similar species. *Lerista karlschmidti* can only be confused with *L. carpentariae* Greer, 1983, *L. cinerea*, *L. hobsoni* Amey, Couper & Worthington Wilmer, 2016 (in Couper *et al.* 2016), *L. storri*, *L. stylis* (Mitchell 1955), *L. vanderduysi* Amey, Couper & Worthington Wilmer, 2016 (in Couper *et al.* 2016) or *L. vittata* Greer, McDonald & Lawrie, 1983, all of which are species with similar patterns and that also have free frontoparietal scales and no forelimbs. Unlike *L. karlschmidti*, these species possess supraciliary scales.

REMARKS

Our primary goal in reassessing *L. karlschmidti* was to determine whether there is justification for leaving this species on the Queensland faunal list. To do so and thereby maintain the long standing status quo of a species with populations in the Northern Territory and Queensland has land management implications. This is particularly so for Queensland as this population has not been seen there for more than 60 years and, under state legislation, would warrant the highest conservation listing. If, as we believe, the species does not occur in Queensland, it is counter-productive to continue searching for it. Restricting it to the Northern Territory allows limited conservation resources to be allocated elsewhere. Further, it has long been postulated that, given the accepted distributions of the Northern Territory and Queensland populations, they were likely to be genetically distinct and represent different species. This work assigns the name to the Northern Territory population. The type locality as stated in the original description is in error. Unfortunately, where the holotype was actually collected remains unknown but, based on current knowledge, is best defined as the northern part of the Northern Territory.

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A significant range extension for the Border Ranges Leaf-tailed Gecko, *Saltuarius swaini* (Wells & Wellington, 1985) (Reptilia: Carphodactylidae)

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ABSTRACT

The recent discovery of *Saltuarius swaini* on Mt Glorious is unexpected due to the site's proximity to a major city. It extends the species' range 80 km north of the nearest known population. Genetic analyses suggests that this is a natural population that has been isolated from the other sequenced, south-east Queensland *S. swaini* populations for an extended period. The species has a limited occurrence on Mt Glorious where it is apparently absent from extensive tracts of suitable rainforest habitat. The rainforest herpetofauna of Mt Glorious is broadly similar to, but more impoverished than, that of the larger southern rainforest blocks of the Border and Main Ranges.
❒ *leaf-tailed gecko, Saltuarius swaini, range extension, rainforest, south-east Queensland, Australia.*

The distribution of *Saltuarius swaini* (Wells & Wellington, 1985) is largely associated with rainforests and adjacent wet sclerophyll forests on basalt formations of the Main Range, Focal Peak and Mt Warning-Tweed shield volcanoes (Couper *et al.* 2008). These occur between latitudes 27° 53′ S–28° 48′ E and are of late Oligocene to early Miocene age (25.5–20.5 mya; Ewart *et al.* 1987; Willmott 2004). Couper *et al.* (2008) reported Mt Tamborine (27° 55′ S, 153° 10′ E) as the northern limit of this species' distribution and although there was suitable habitat in the D'Aguilar Range, 80 km to the north, there were no records from this area.

On the evening of the 16th September 2016, B. Revell was head-torching for frogs in rainforest on Mt Glorious in the D'Aguilar Range (27° 20′ S, 152° 46′ E), west of Brisbane, and found a large leaf-tailed gecko (Fig. 1) of the genus *Saltuarius* Couper *et al.*, 1993, on the trunk of a Strangler Fig Tree *Ficus* sp. The site was revisited four days later and two additional geckos were found and photographed *in situ*. Subsequent examination of these images showed that the geckos were morphologically similar to *S. swaini*.

FIG. 1. *Saltuarius swaini*, Mt Glorious. (Image: Ben Revell).

This discovery was unexpected because it occurred in a well-visited area, close to a major city. The observation raised several questions. Is this a population of *S. swaini* or an undescribed species? If *S. swaini*, is this population natural or a recent introduction? To address these questions, additional surveys were conducted to examine the habitat, obtain close-up photographs of the animals, and collect tissue samples (tail tips) for genetic analyses.

METHODS AND RESULTS

Observations. The initial photographs taken on the 20th September 2016 were of two adult-sized *Saltuarius*, both with regrown tails, high on the trunks of separate trees. Whilst the form and pattern of these geckos was consistent with that of *S. swaini*, the images were not sufficiently clear to show any of the finer diagnostic characters. The site was revisited (by BR) four additional times (21st September, 3rd October, 25th October and 31st October, 2016) and 6 geckos were sighted. An individual was found low enough on the trunk of a fig tree to take a series of close-up images. These showed that the gecko had low, conical flank tubercules and a heterogeneous mix of small and large scales above the supralabials, both of which are diagnostic characters for *S. swaini* (see Couper *et al.* 1993). The site was visited again on the 5th of November and the 14th of November to obtain tail tip samples from three individuals. During these surveys, at least 10 individual geckos were identified from areas proximate (i.e., within 250 m) to the site where leaf-tailed geckos were first seen. On the 15th of November, two adult leaf-tailed geckos were observed on a large fig tree approximately 2 km from the original site.

Site description. The leaf-tailed gecko habitat is located north-west of the Mount Glorious township, within D'Aguilar National Park. The vegetation consists of subtropical rainforest (Regional Ecosystem 12.8.3. Complex notophyll

FIG. 2. The initial site showing a large Strangler Fig Tree (*Ficus* sp.) growing on a rocky, western facing slope with little understorey. Several leaf-tailed geckos were observed on this tree. (Image: Ben Revell).

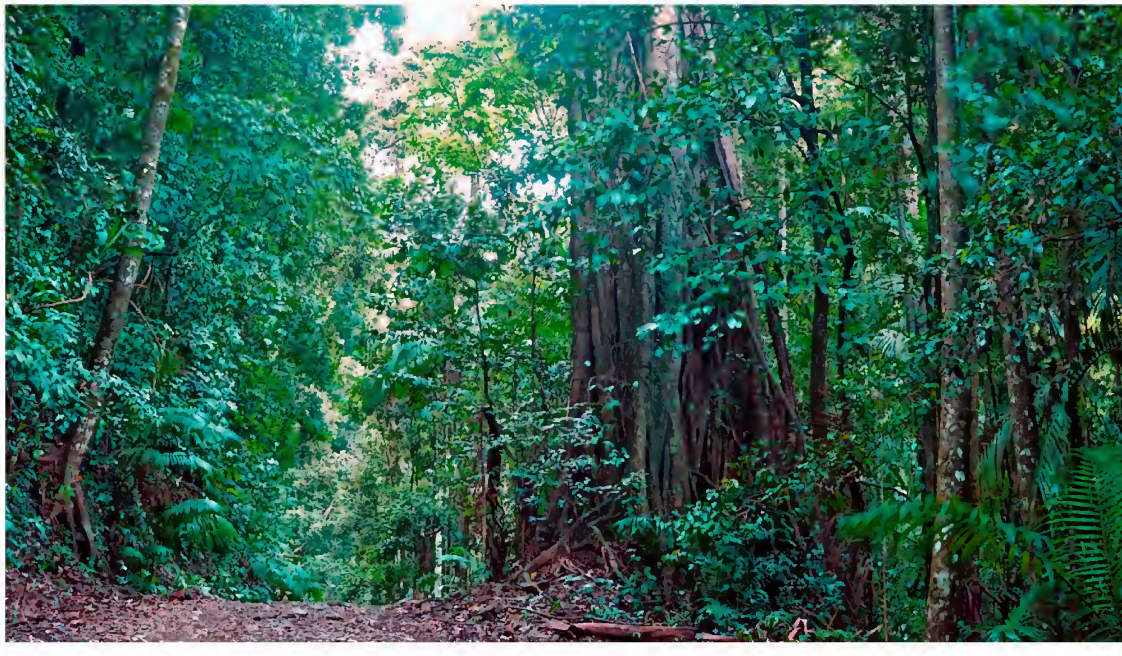

FIG. 3. The second leaf-tailed gecko site, approximately 2 km from the initial site, showing a large Strangler Fig (*Ficus* sp.) on which two geckos were seen. This site has a well-developed understorey and no surface rock. (Image: Ben Revell).

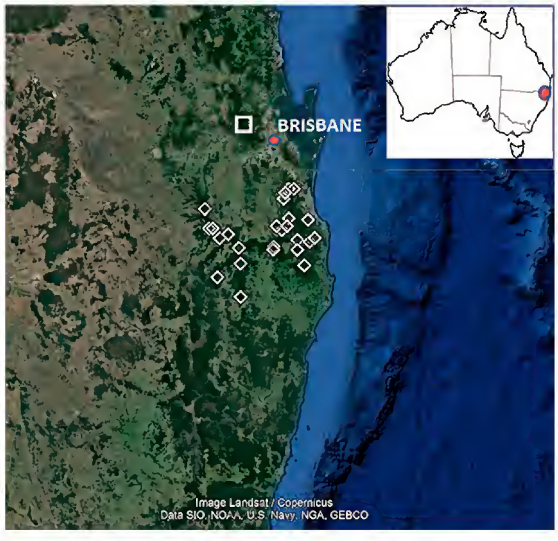

FIG. 4. Known distribution of *S. swaini*. The square symbol shows the Mt Glorious population which is widely disjunct from the populations to the south (diamond symbols; see Couper *et al.* 2008). Inset shows general region on map of Australia. Background map - Google Earth.

vine forest on Cainozoic igneous rocks. Altitude <600 m; Queensland Herbarium 2016) which extends for several kilometres on either side of the main Mt Glorious ridgeline. The initial site has a relatively open, sparse understorey on a jumbled rocky substrate comprised of Oligocene basalt that caps the Mt Glorious plateau, extending approximately 500 m (Willmott & Stevens 2005). At this site, the core habitat is a particularly rocky area (rocks to about one metre in circumference; Fig. 2) extending approximately 200 m by 100 m on a western facing slope. A second site, approximately 2 km from the first, is also on a western slope descending from the same ridgeline as the first. Whilst this site also has subtropical rainforest with large fig trees, it has a well-established understorey and no surface rock (Fig. 3).

Genetics. Two samples from Mt Glorious were sequenced for a section of cytochrome b mtDNA (as per Hoskin *et al.* 2003) and aligned against sequences available on GenBank (*S. swaini*: EU625318, EU625319 and EU625320 from Main Range; EU625323 from Tamborine Mountain; EU625322 from Lamington NP; EU625324 from Mt Warning; EU625326 from Border Ranges; *S. wyberba* Couper, Schneider & Covacevich, 1997: EU625333; *S. salebrosus* (Covacevich, 1975): EU625341). Based on 360 base pairs, the two Mt Glorious samples are closely allied to *S. swaini* but sit outside of all other *S. swaini* sequences at an average divergence of 4.1% (C. Hoskin, unpub. data). Excluding Mt Glorious, average sequence divergence amongst the sites within *S. swaini* is just 1.0%. The Mt Glorious samples were 15.8% and 21.8% divergent from *S. wyberba* and *S. salebrosus*, respectively. Although only nine *S. swaini* sequences were included in this analysis, these come from sites across much of the species' range. The genetic data illustrates that the Mt Glorious population is *S. swaini*. *Saltuarius swaini* occurs in the coastal ranges of southeast Queensland and northern NSW (between latitudes 27° 53′ S–28° 48′ S). The closest *S. swaini* populations to Mt Glorious are on Mt Tamborine, ~80 km to the south-east (Fig. 4) and Main Range National Park, a similar distance to the south-west. The genetic divergence of 4% strongly suggests that this is a natural population that has been isolated from other *S. swaini* populations for an extended period. Using a coarse molecular clock for protein-coding mtDNA (Borsboom *et al.* 2010; Moritz *et al.* 2000), it is estimated that this population has been isolated for more than one million years.

DISCUSSION

It is remarkable that *Saltuarius swaini* has not previously been detected on Mt Glorious. The rainforests of Mt Glorious are amongst the most visited in south-east Queensland, being easily accessible and in close proximity to Brisbane. They are home to a rich fauna of nocturnal vertebrates and have been the focus of frequent night-driving and head-torching activities. In other areas of south-east Queensland (for example the Border Ranges, Lamington NP) leaf-tailed geckos are commonly encountered on roads and walking tracks. The Mt Nebo to Mt Glorious drive is particularly popular amongst reptile enthusiasts because nocturnal snakes and other reptiles are often encountered

on the roads. These forests have also been heavily investigated during targeted, long-term, field studies, one which Conrad Hoskin participated in, surveyed rainforest frogs on a rainforest stream transect in the headwaters of Love Creek, about 3 km north of the Mount Glorious township. Many surveys were conducted over five years (1996–2000) and all vertebrates were targeted both on the stream transect and on the walk though rainforest to and from the site. Similarly, Tony Hiller, a keen naturalist and long-term resident of Mt Glorious (~40 years), has no records of leaf-tailed geckos from this area. Nor does Wil Buch, a Queensland Parks and Wildlife Service ranger who resided on Mt Glorious for seven years and led an average of two guided night walks per week during this time, but not in the precise area where leaf-tailed geckos are now known. Co-author, Steve Wilson lived on Mt Nebo for 12 years and frequently drove the roads and head-torched in the forests at night. That no leaf-tailed geckos were seen during these activities, and activities by many other wildlife enthusiasts over the years, suggests a very limited occurrence on Mt Glorious. We initially thought this could indicate that the geckos had been recently introduced, but the genetic data strongly suggest a natural population. The Mt Glorious population is genetically distinct from likely source populations (Mt Tamborine, Lamington NP, Main Ra.); indeed the genetic divergence (4%) is greater than that seen amongst all other *S. swaini* populations sequenced.

There are currently no known records from the more frequently visited eastern side of the range, which includes the walking tracks originating from Maiala Picnic Ground. The rainforest at Maiala is continuous with that at the leaf-tailed gecko sites and to all purposes, appears to be ideal leaf-tailed gecko habitat, with numerous fig trees and other large trees with hollows and epiphytes in which to shelter. The same is true of the rainforest at Boombana Picnic Area on Mt Nebo, albeit with a much smaller rainforest extent in that area. Yet, in view of the aforementioned activities, leaf-tailed geckos appear to be absent from both these areas. Given the very recent discovery at Mt Glorious, however, their presence elsewhere in the D'Aguilar Range cannot be ruled out, particularly in other pockets of rockier habitat around Mt Glorious. The occurrence of leaf-tailed geckos in other areas of the D'Aguilar Range warrants further investigation with targeted searches of suitable habitat.

The abundance of rock at the first leaf-tailed gecko site could be seen as significant and as having a role in preserving this species in historically drier times, due to the cooler, moister conditions provided by layered rock habitats (see Couper & Hoskin 2009). However, the geckos are not found directly on the rocks but rather occur on the fig trees growing amongst them. Additionally, as pointed out above, the second site (two kilometres away) is not rocky and once again the geckos occur on the fig trees (although surveys around this site could reveal nearby rocky habitat). Given this apparent preference for trees, it seems odd that they don't occur more widely through the rainforests on both Mt Nebo and Mt Glorious. Perhaps rocky areas provided an important refuge in the past, but then one would expect the geckos to have expanded back out of these areas over thousands of years to recolonise the surrounding well-developed rainforest. It is interesting to note that the Marsupial Frog, *Assa darlingtoni* (Loveridge 1933), another rainforest endemic of south-east Queensland and north-east New South Wales, also has a very patchy distribution on Mt Glorious. This species occurs in moist gullies and rocky slopes on Mt Glorious, including the rocky leaf-tailed gecko site. Although other areas of Mt Glorious appear to currently provide suitable habitat for *S. swaini* and *A. darlingtoni*, it may be the drier times during the evolutionary history of these forests that shaped the fine-scale distributions of these low vagility rainforest species.

The discovery of leaf-tailed geckos adds to the herpetological diversity known for Mt Glorious, which now includes eight wet-forest associated reptiles (*S. swaini*, *Bellatorias major* (Gray, 1845) *Karma murrayi* (Boulenger, 1887), *Lampropholis couperi* Ingram, 1991, *Saproscincus rosei* Wells & Wellington, 1985, *Lophosaurus spinipes* (Duméril & Duméril, 1851) *Hoplocephalus stephensii* Krefft,

1869 and *Tropidechis carinatus* (Krefft, 1863)) and five frogs (*Assa darlingtoni*, *Taudactylus diurnus* Straughan & Lee, 1966, *Litoria chloris* (Boulenger, 1893) , *Litoria pearsoniana* (Copland, 1961) and *Mixophyes fasciolatus* Günther, 1864). This herpetofauna is broadly similar to, but impoverished, compared to that of the larger southern rainforest blocks of the Border and Main Ranges. Of the wet-forest obligate species, *Coeranoscincus reticulatus* (Günther, 1873), *Mixophyes fleayi* Corben & Ingram, 1987 and *Lechriodus fletcheri* (Boulenger, 1890) are present on the Border and Main Ranges but have not been recorded from the D'Aguilar Range (Mt Glorious). The apparent absence of *C. reticulatus* and *M. fleayi* is of particular interest as both species also occur in rainforests to the north, in the Sunshine Coast hinterland. Three species of *Saproscincus* (S. *rosei*, *S. challengeri* (Boulenger, 1887), and *S. spectabilis* (De Vis, 1888)) are found in the Border Ranges but only *S. rosei* occurs in the D'Aguilar Range. The Border Ranges also harbour two skinks that are restricted to higher elevations than are available in the D'Aguilar Range: *Karma tryoni* (Longman, 1918) and *Harrisioniascincus zia* (Ingram & Ehmann, 1981) . Additionally, both the Border and Main Ranges support a frog belonging to the genus *Philoria* Spencer, 1901: *P. loveridgei* Parker, 1940 on the Border Range and *P. kundagungan* (Ingram & Corben, 1975) on the Main Range. As for the other species listed above, no *Philoria* are known from the D'Aguilar Range. Conversely, two elements of the D'Aguilar Range rainforest herpetofauna are not found in other rainforests where *S. swaini* occurs. The skink *Lampropholis couperi* is common on both Mt Nebo and Mt Glorious (and ranges to the north), and the frog *Taudactylus diurnus* was present on Mt Glorious (and ranges to the north) until its likely extinction in the 1970s. With the addition of *S. swaini* to the Mt Glorious faunal list, it is conceivable that *C. reticulatus* and some of the other species 'missing' from its rainforest herpetofauna, will also be found in the D'Aguilar Range with continued search effort.

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Revision of the land snail genus *Pallidelix* Iredale, 1933 with the description of new species from the central highlands of inland Queensland (Gastropoda: Eupulmonata: Camaenidae)

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ABSTRACT

Pallidelix Iredale, 1933 is revised on the basis of conchological and anatomical morphology. Nine new species *Pallidelix lonesome* sp. nov., *P. expeditiana* sp. nov., *P. potteri* sp. nov., *P. staricki* sp. nov., *P. lambkinae* sp. nov., *P. moffatt* sp. nov., *P. grandis* sp. nov., *P. minerva* sp. nov. and *P. zamia* sp. nov. are described. Penial pilaster patterns and shell sculpture were considered significant species delimiting characters. A key to species is presented. Two species are shown to have relatively widespread distributions while the majority have small circumscribed distributions in scattered and isolated patches of vine thicket. Two species placed in *Pallidelix* by Stanisic *et al.* (2010) from south-eastern Queensland, *viz. H. bennetti* Brazier 1872 and *P. chinchilla* Stanisic, 2010 are herein excluded from the genus. As part of this revision the taxonomic status of the problematic *Helix expeditionis* Cox, 1868 (considered a synonym of *P. greenhilli* by Stanisic *et al.* 2010) is also discussed. ❐ *Pallidelix, Eupulmonata, Camaenidae, revision, systematics, morphology, new species, Queensland, Australia.*

A mega-clade of semi-arid to arid-adapted, medium-sized to large camaenids inhabiting inland parts of Queensland, coastal and inland New South Wales and the arid areas of South Australia and the Red Centre was identified by Hugall & Stanisic (2011: Clade 3). The Queensland endemic *Pallidelix* Iredale, 1933 (type species. *Helix greenhilli* Cox, 1866) is one of these Clade 3 genera with species centred in semi-arid inland southern and mid-central Queensland in the Brigalow Lands bioregion.

Pallidelix greenhilli (Cox, 1866) was described from the 'Upper Dawson River' which has its headwaters in the Carnarvon Ranges, SCQ. Based on limited material Stanisic *et al.* (2010) considered that a single species, *P. greenhilli*, inhabited all of the Carnarvon and Expedition Ranges and nearby surrounding areas. Stanisic *et al.* (2010) also included two additional species from south-eastern Queensland in the genus (*Helix bennetti* Brazier, 1872 and *Pallidelix chinchilla* Stanisic, 2010) on the basis of grossly similar shell sculpture but conditional on a full revision of the genus. *P. simonhudsoni* Stanisic, 2015 was subsequently described from vine thickets of Carnarvon Station Reserve and detailed morphological investigations at the time revealed the possible presence of other putative *Pallidelix* species in south and mid-central Queensland. However, the specimen base of available material was not considered sufficient in its geographic coverage to allow for a full revision of the genus.

The recent donation of a large amount of material (chiefly dead shells) to the QM from the central highlands of inland Queensland has prompted this revision. This material included many new locality records for the genus and

was critical in establishing the distribution limits of putative species based on shell characters which could be linked to species recognition changes in terminal genitalia. Although some spirit material was available and DNA extraction attempted, the resulting cladogram was inconclusive and conflicting with anatomical results in establishing the validity of species. Hence, this revision is based on shell morphology and reproductive anatomy. The two additional species placed in *Pallidelix* by Stanisic *et al.* (2010) from south-eastern Queensland, *viz. H. bennetti* and *P. chinchilla*, are herein excluded from the genus and will be dealt with elsewhere. As part of this revision the taxonomic status of the problematic *Helix expeditionis* Cox, 1868 (considered a synonym of *P. greenhilli* by Stanisic *et al.* 2010) is also discussed.

MATERIALS AND METHODS

Material used in this study is held in the collections of the Queensland Museum (QMMO). Studies of shell characters were carried out on specimens in the museum's dry collection (RC) and anatomical studies were based on ethanol preserved samples (SC). Age cohorts in individual lots are identified by the abbreviations A (adult) and SA (subadult). Specimens were studied using a WILD M5 stereo microscope and anatomical photographs were taken with a NIKON 4200 Coolpix camera with microscope attachment. Measurements of shell characters (height, diameter) were made using callipers with a precision of 0.01 mm. Whorl counts were made to the nearest 0.125 whorl. Where possible, at least two representatives of each species were dissected in order to confirm constancy of reproductive structures. Historic type material was loaned for the study by the Australian Museum (Sydney).

Differences in reproductive anatomy between species of *Pallidelix* relate to changes in penial pilaster configuration with other features typical of the generic base plan. Hence, most genitalic illustrations presented herein only feature the dissected penial apparatus of individual species rather than the entire genitalia.

ABBREVIATIONS

General. Ck, creek; MCQ, mid-central Queensland; Mt, Mount; Mtn, mountain; NP, National Park; Ra, range; Rd, road; SCQ, south-central Queensland; SEQ, South-East Queensland; sevt, semi-evergreen vine thicket; SF, State Forest; Stn, Station; Tbld, Tableland.

Delimitation of species in *Pallidelix*. In the absence of material for molecular analysis species were delimited on the basis of variation in shell characters generally considered useful guides to species within the family (size, shape, coiling and sculpture) and differences in the male terminal genitalia, specifically variation in the internal architecture of the penial chamber. Conchological differences such as size will often relate to functionality within local environmental regimes. Hence, care needs to be taken when assessing such differences in isolation. However, when correlated with changes in shell shape and coiling pattern (expanded body whorl), size can be a useful species-specific character. Shell sculpture in *Pallidelix* is low-relief (microridgelets and tiny pustules) and deemed to have little environmental function and so is not considered to be readily subject to external selective pressures. Hence, subtle but significant shifts in sculptural patterns are more likely to be inherited and, when correlated with other conchological characters, are likely to be significant at the species level. Shell sculpture that is considered to be species-delimiting in *Pallidelix* consists of variation in the intensity of the microridgelets *versus* pustules and also changes in their ontogenetic disposition.

Genital changes within *Pallidelix* chiefly consist of variations in penial pilaster configuration with no major fundamental shifts in basic structures from the generic pattern. Species recognition changes in genitalia in the Camaenidae normally involve changes in penial pilaster pattern and this has been shown to be the case within a wide range of taxa (Solem 1992, Köhler 2011). Greatest change occurs under conditions of congeneric sympatry. The fact that the species of *Pallidelix* are allopatric or at most parapatric, suggests that

genitalic differences will be conservative and presumably due to genetic drift following long term isolation rather than a result of species-species interactions under sympatry. And this is indeed the case. Some intraspecific variation may occur in widespread species however, these need to be interpreted in conjunction with other conchological and anatomical characters when identifying species.

In this study, a species was identified by unique set of non-correlated conchological features coinciding with a shift in the number, shape and length of penial pilasters.

SYSTEMATICS

Infraorder EUPULMONATA

Superfamily HELICOIDEA

Family CAMAENIDAE

Genus ***Pallidelix*** Iredale, 1933

Pallidelix Iredale, 1933: 47; Iredale,1937: 36; Smith, 1992: 140; Stanisic *et al.*, 2010: 440 (*partim*); Stanisic, 2015: 56.

Type species. *Helix greenhilli* Cox, 1866-by original designation.

Taxonomic issues. *Pallidelix* Iredale, 1933 was introduced to accommodate a single species (*Helix greenhilli* Cox, 1866) from the rather broad type locality of 'Upper Dawson River', south central Queensland. Little attention was given over to comparative morphological detail…'the thin shell, rounded whorls, pale unicolor shade, umbilical characters, and microscopic sculpture disagree altogether with any of the preceding, and necessitate the introduction of a new generic name' (Iredale, 1933). Fortunately three syntypes, which are the only known specimens of the original collection by a Mr Greenhill, have survived for the purpose of adequately describing the species and providing a basis for comparisons and generic diagnosis.

Diagnosis. Shell large (20-30 mm diameter) to very large (30-40 mm diameter), yellowish brown to brown often with a lighter base and frequently with a reddish brown subsutural band, occasionally with an overall pinkish tinge. Spire weakly to moderately elevated, whorls rounded to occasionally shouldered below the periphery, body whorl in some species extremely expanded. Protoconch of 1.75 whorls sculptured with crowded, radially arranged, irregularly shaped pustules (Fig. 1A) , teleoconch sculpture generally with crowded pustules on the early whorls and a variable pattern of pustules and oblique to zigzag microridgelets on the last three whorls (Fig. 1B, C), sometimes becoming obsolete on the last half of the body whorl, occasionally adorned with periostracum; curved, weak to strong radial growth lines present in most species; umbilicus narrowly open and reduced to a lateral crack, or closed. Penis elongate, with a sheath, internally with an apical smooth and tapered papillate verge with a terminal pore; walls of penial chamber with smooth, thick longitudinal pilasters apically and a variable pattern of obliquely disposed longitudinal pilasters medially and thin irregular corrugated pilasters or pustules basally; epiphallus with a very thick, ascending arm, strongly reflexed and slightly twisted at the point of reflexion before giving rise to an equally long but thinner descending arm; epiphallic caecum situated near the point of reflexion; a long, thick finger-like epiphallic flagellum present at the epiphallus-vas deferens junction. Animal with coloured (red or beige) mantle.

Range. Currently considered to extend from Gurulmundi SF, north of Miles, SEQ in the south through the Carnarvon and Expedition Ranges to Springsure, SCQ and north to the Drummond Range, west of Emerald, MCQ.

Remarks. *Pallidelix* Iredale, 1933 as herein defined is distinguished by a combination of conchological features (shell shape, coiling pattern, teleoconch sculpture) and reproductive anatomy (terminal male genitalia). Species are almost exclusively allopatric occurring mostly within isolated patches of vine thicket. Protoconch sculpture consists of irregular radial microridgelets and scattered pustules (Fig. 1A). The teleoconch sculptural features are a combination of microridgelets and tiny pustules (Fig. 1B, C) which differ in their individual intensity

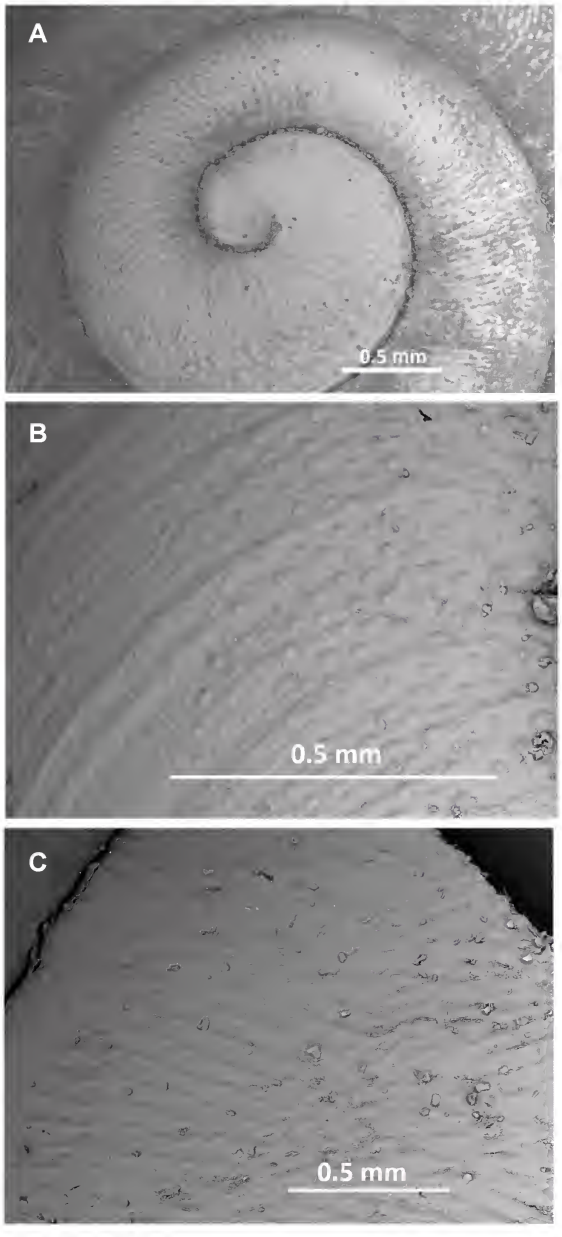

FIG. 1. Scanning electron micrographs showing aspects of *Pallidelix* sculpture. **A**, irregular microridgelets and scattered pustules on the protoconch of *P. simonhudsoni* Stanisic, 2015; **B**, crowded pustules on the teleoconch of *P. minerva* sp. nov.; **C**, oblique and zigzag microridgelets on the teleoconch of *P. expeditiana* sp. nov.

between the various species and display a high level of local geographic consistency. Shell size, shape and coiling pattern are informative in several species but show no geographic consistency. Conchologically *Pallidelix* differs from the sometimes sympatric and similarly looking *Lynfergusonia* by having a shell sculpture that includes oblique to zigzag microridgelets which are lacking in the latter. In contrast to the former *Lynfergusonia* has a sculpture of dense pustules over the entire teleoconch. Anatomically *Pallidelix* is distinguished by having an elongate muscular penis with a series of smooth, thick, fleshy, either straight or anastomosing, longitudinal pilasters apically, and a smooth, tapering penial verge with a terminal pore. In contrast *Lynfergusonia* has a sculptured verge with the epiphallic pore located at the base of the verge and numerous irregularly shaped, small, crowded pustular pilasters; There is no caecum and the epiphallic flagellum is thin and spindly in contrast to the thick, finger-like flagellum of *Pallidelix* (Stanisic, unpublished).

Within the geographic range of *Pallidelix* there are also other yet-to-be described camaenid genera and species which possess some similar shell characters (e.g. pustules, zigzag microridgelets), but most significantly, differ in configuration of the terminal male genitalia, particularly the internal architecture of the penis.

Pallidelix greenhilli (Cox, 1866)
(Figs 2A-B, 3A-C, 12A)

Helix greenhilli Cox, 1866: 46; Cox, 1868: 40.
Pallidelix greenhilli (Cox). Iredale, 1933: 47; Iredale, 1937: 36; Smith, 1992: 140; Stanisic *et al.*, 2010: 440, sp. 688.

Preferred common name. Dawson River Woodland Snail.

Taxonomic issues. A specimen labelled syntype (registration number AMSC.5767) and one other specimen (AMSC.101192) which may also be considered a syntype are housed in the Australian Museum, Sydney. An additional syntype (NMWZ1955.158.880) resides in the National Museum of Wales (Smith 1992). Specimen AMSC.5767 was selected as lectotype (Fig. 2A).

A major issue in the past has been the inability to associate the type series of *H.*

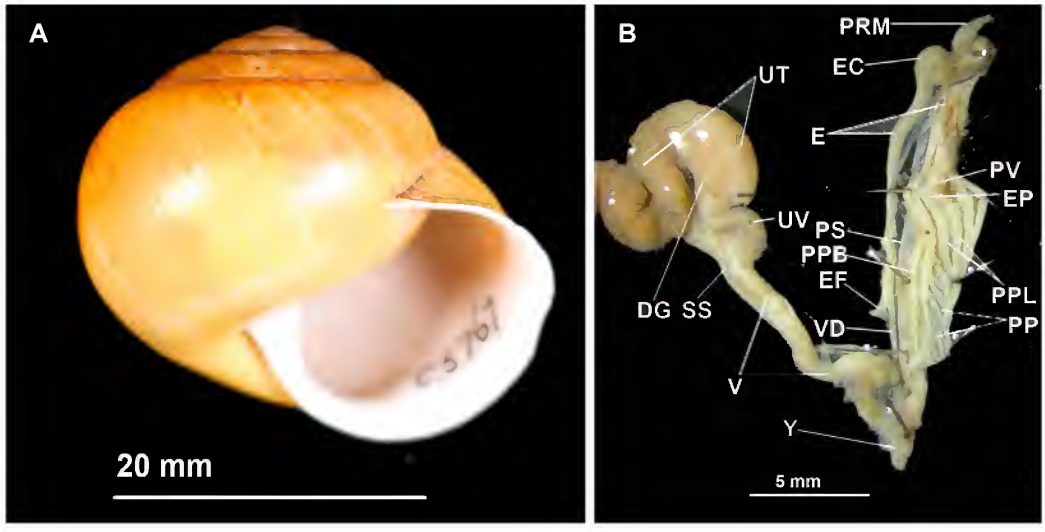

FIG. 2. *Pallidelix greenhilli* (Cox, 1866). **A**, lectotype, AMSC5767; **B**, genitalia, QMMO79091.

greenhilli from the type locality (Upper Dawson River) with any museum material from within the extensive upper Dawson River drainage. This matter was recently resolved with the donation to the Queensland Museum of a large number of specimens from the upper reaches of the Dawson River which contained material considered conchologically similar (size, shape and sculpture) to *P. greenhilli*. Stanisic *et al.* (2010) took a broad view of this species and judged it to range through a large part of the sandstone belt (Carnarvon and Expedition ranges) to the Minerva Hills near Springsure, MCQ. However, as a result of this revision *P. greenhilli* is herein restricted to the Expedition Resource Reserve area of the Expedition Range based on the shell size, shape and microsculpture of the syntypes most closely resembling those of specimens from that area.

Material examined. (All south central Queensland).

Lectotype (herein designated). AMSC.5767, Upper Dawson River (herein restricted to the Expedition Resource Reserve at the southern end of the Expedition Range), coll. Mr Greenhill, ex. Cox coll. Height of shell 23.16 mm, diameter 29.06 mm, h/d 0.797, whorls 5.875.

Paralectotypes. AMSC.101192, 1A RC; NMWZ1955.158.880 (*fide* Smith 1992), A RC; both same data as lectotype.

Other material examined. QMMO79091, 4A SC/13A RC; QMMO85256 2A, 2SA RC, Expedition Resource Reserve, adjoining "Yebna", c.60 km NNE Injune, 25°37'18"S, 149°07'21"E, sevt, in and under logs, coll. C. Eddie, 21.vii.2009; QMMO54826, 2A,1SA RC, Taroom, W near "Yebna", 25°41'22"S, 149°06'37"E, vine thicket, coll. P.Grimshaw, W. McDonald, 12.v.1993.

Diagnosis. Shell large, subglobose, yellowish brown to brown with a yellowish green base; teleoconch sculpture consisting of prominent, moderately crowded, oblique to zigzag microridgelets and reduced pustulation. Penial chamber apically with 5 fleshy longitudinal pilasters, medially with a prominent bifurcate longitudinal pilaster and a series of thinner fleshy obliquely oriented pilasters, basally with a series of irregularly arranged pustulose pilasters.

Description. Shell large, shiny, subglobose, yellowish brown to brown with a very weak reddish brown subsutural band and yellowish green base; spire weakly elevated, whorls 5.625-6.0 (mean 5.875), evenly rounded, the last descending rapidly in front (Fig. 2A). Height of shell 21.94-26.18 mm (mean 23.88 mm), diameter of shell 27.45-31.04 mm (mean 29.40 mm), h/d 0.747-0.874 (mean 0.812). Protoconch as for genus. Teleoconch sculpture consisting of moderately crowded and prominent, oblique

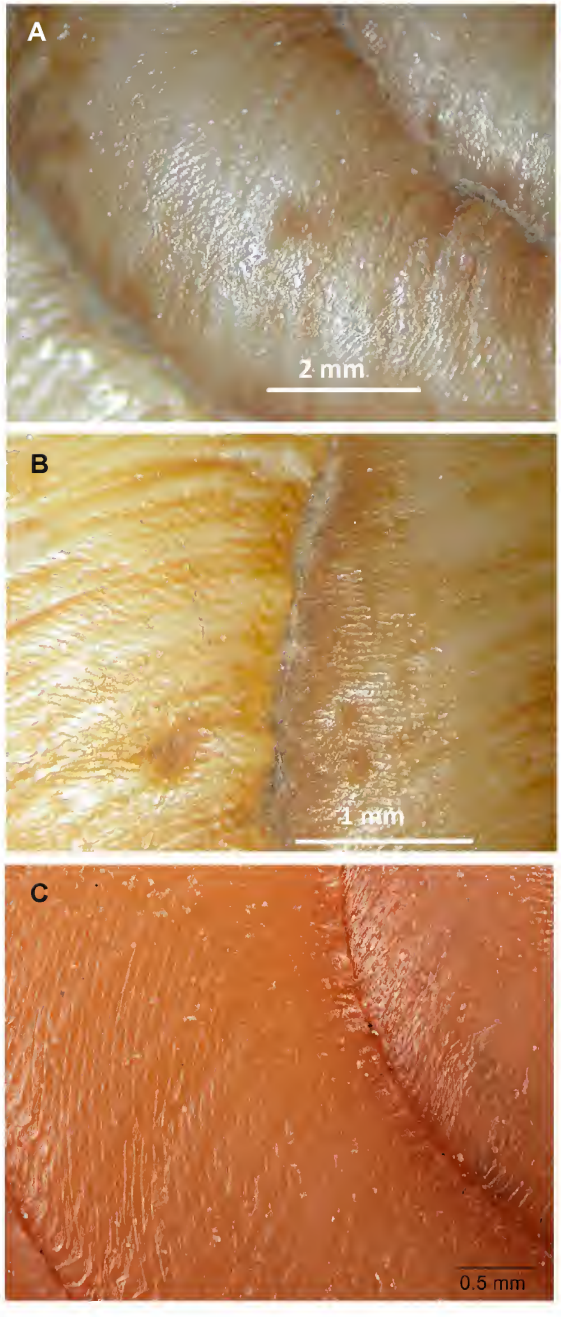

FIG. 3. Sculpture in *Pallidelix greenhilli* (Cox, 1866). **A**, lectotype, AMSC5767; **B**, Expedition Resource Reserve, QMMO79091; **C**, paralectotype, AMSC101192. Image C: Geoff Thompson, QM Digital Imaging Unit.

to zigzag microridgelets continuous on body whorl, scattered pustules near the sutures otherwise pustulation reduced; base shiny and smooth. Aperture roundly lunate, lip white, expanded and reflected; umbilicus reduced to a lateral crack. Based on 17 measured adults [QMMO79091 (13), QMMO54826 (2), QMMO85256 (2)].

Genitalia. (Fig. 2B) Penis (P) long, tapered with slightly expanded apical bulb, thin sheath (PS) present; internally with a smooth papillate verge (PV), upper walls of penial chamber with 5 straight, fleshy longitudinal pilasters (PPL), medially with a prominent bifurcate longitudinal pilaster and a series of thinner fleshy obliquely oriented pilasters (PP), basally with a series of irregular pustulose pilasters. Epiphallus (E) with relatively long, thick, muscular, curved ascending arm enveloped and partially folded within penial sheath, strongly reflexed and twisted before giving rise to a thinner, relatively short descending arm; epiphallus entering penis through a simple pore (EP) situated terminally on verge. Penial retractor muscle (PRM) inserted at the junction of the two arms of the epiphallus adjacent to an epiphallic caecum (EC). Vas deferens (VD) thin, attached to penial sheath with connective tissue; a long, thick finger-like epiphallic flagellum (EF) present at epiphallus-vas deferens junction, tightly bound to vas deferens. Vagina (V) equal to length of penis. Atrium (Y) simple. Free oviduct (UV) shorter than vagina; bursa copulatrix situated at the base of the albumen gland with a slender stalk (SS); prostate (DG), uterus (UT) and hermaphroditic duct without unusual features. Based on two dissected specimens (QMMO79091).

Distribution. Herein restricted to the Expedition Resource Reserve at the southern edge of the Expedition Range near the Dawson River, SCQ.

Habitat. Vine thicket among eucalypt woodland; living under logs and rocks (Fig. 5A).

Remarks. Conchologically *Pallidelix greenhilli* (Cox 1866) is distinguished by a combination of large shell with weakly elevated spire, sculpture

of prominent oblique to zigzag microridgelets which persist onto the last part of the body whorl and reduced pustulation (Fig. 3A-C). Anatomically the penial pilaster pattern, particularly the prominent medial bifurcate longitudinal pilaster is a structure which readily separates *P. greenhilli* from its congeners all of which lack this feature (Fig. 12A). *P. expeditiana* sp. nov. has a shell with increased pustulation and longitudinal penial pilasters which may anastomose and become obliquely disposed medially before straightening basally.

Pallidelix lonesome sp. nov.
(Figs 4, 6A-C, 12B, 19A)

Etymology. For Lonesome National Park.

Preferred common name. Lonesome Woodland Snail.

Material examined. (All south central Queensland).

Holotype. QMMO85326, Lonesome NP, 25°29′41″S, 148°49′42″E, brigalow woodland/vine thicket, under rocks on ground, coll. C. Eddie, W. Stanford, W. McDonald, 10.vi.1999. Height of shell 30.31mm, diameter 31.19mm, h/d 0.972, whorls 6.375.

Paratypes. QMMO65168, 1A,3SA SC/10A RC, same data as holotype; QMMO79360, 4A RC, NE Injune, Lonesome Holding at south end of Battleship, 25°29′48″S, 148°52′32″E, sevt/*Brachychiton*/*Ficus*, under sandstone rocks, coll. C. Eddie, W. McDonald, 26.iv.2004; QMMO85467, 13A RC, Injune, 51.8 km NE at Lonesome Holding, Popes Nose scrub, Arcadia Valley, 25°29′37″S, 148°54′31″E, sevt on sandstone ridge slope under logs and dead on ground, coll. C. Eddie, 18.x.2011; QMMO85469, 12A RC, Injune, 46.1 km NE Expediton NP (Lonesome Section), WSW of The Candlesticks, 25°31′01″S, 148°51′12″E, sevt with emergent *Brachychiton* /*Acacia harpophylla*, gully on slope of sandstone ridge, under and inside logs and dead on ground, coll. C. Eddie, W. McDonald, 26.iv.2004.

Other material examined. QMMO65167, 2A,1SA SC/10A RC, Lonesome NP, Arcadia Valley Rd, 1.6km ME lookout turnoff, 25°29′26″S, 148°48′58″E, brigalow woodland/vine thicket, under rocks, coll. C. Eddie, 27.v.1999; QMMO65337, 6A,2SA RC, Lonesome NP, Arcadia Valley Rd, 1.6km ME lookout turnoff, 25°29′26″S, 148°48′58″E, brigalow woodland/vine thicket, under rocks, coll. C. Eddie, 3.iv.1997; QMMO73014, 3A SC/8A,2SA RC, Injune, NE on hill adjacent to NW corner of Expedition NP, Lonesome Section, 25°28′47″S, 148°49′30″E, sevt/*Brachychiton*, coll. C. Eddie, 20.i.2004; QMMO80651, 3A RC, Injune, 50.3 km NE at Lonesome Holding, Arcadia Valley, 25°30′03.5″S, 148°53′53.3″E, brigalow, under logs and dead on ground, coll. C. Eddie, 27.x.2011; QMMO79361, 1A RC, NE Injune, Lonesome Holding at Candlesticks Gully, 25°31′07″S, 148°51′08″E, sevt, under rocks and logs, coll. C. Eddie, W. McDonald, 26.iv.2004; QMMO85260, 2A RC, Injune, 52.1 km NE at Lonesome Holding, Arcadia Valley, 25°28′29″S, 148°53′25″E, brigalow regrowth, under logs, coll. C. Eddie, 29.x.2011; QMMO85263, 6A RC, NE Injune, Lonesome Holding at Candlesticks Gully, 25°31′19″S, 148°50′35.5″E, sevt in gully below sandstone ridge, under rocks and logs, coll. C. Eddie, 22.vii.2009; QMMO85261, 16A,1SA RC, NE Injune, Lonesome Holding at south end of Mt Jiman (=Battleship), 25°29′23″S, 148°52′47″E, sevt with emergent *Flindersia australis* at base of sandstone cliff, under logs and among rocks, coll. C. Eddie, 16.xii.2003; QMMO85472, 8A RC, Injune, 49.5 km NE at Lonesome Holding at south end of The Battleship, Arcadia Valley, 25°29′43″S, 148°52′36″E, sevt/*Brachychiton*/*Ficus*, steep slope of sandstone ridge, in leaf litter under logs and under/among rocks, coll. C. Eddie, W. McDonald, 26.iv.2004.

FIG. 4. Teleoconch sculpture in *Pallidelix lonesome* sp. nov., QMMO85326.

Diagnosis. Shell large to very large, globose with an expanded body whorl, yellowish brown to brown, occasionally with a lighter coloured base and generally with a reddish brown subsutural band; teleoconch sculpture consisting of low, crowded, oblique to zigzag microridgelets and weak scattered pustules, reduced on last part of body whorl. Penis with 5-6 fleshy longitudinal pilasters apically becoming thin and corrugated toward the atrium.

FIG. 5. *Pallidelix* habitats. **A**, *P.greenhilli* (Cox, 1866): Expedition Resource Reserve, SCQ; **B**, *P. lonesome* sp. nov.: Lonesome Holdings, SCQ; **C-F**, *P. expeditiana* sp. nov.: **C**, Sunnyholt Stn, SCQ; **D**, Moonah Stn, SCQ; **E**, Nugga Nugga Stn, SCQ; **F**, Fairview Stn, SCQ. Images: C. Eddie.

Description. Shell large to very large, globose, yellowish brown to brown, occasionally with a yellowish base, generally with a reddish brown subsutural colour band; spire moderately elevated, whorls 6.0-6.250 (mean 6.125), evenly rounded to slightly angled below the periphery in some, body whorl expanded, descending rapidly in front (Fig. 6A-C). Height of shell 27.17-31.02 mm (mean 28.80 mm), diameter of shell 29.67-35.53 mm (mean 31.71 mm), h/d 0.804-0.978 (mean 0.907). Protoconch as for genus. Teleoconch sculpture consisting of low, crowded oblique to zigzag microridgelets and weak scattered pustules, reduced on last part of body whorl which sometimes appears smooth; base shiny and smooth. Aperture roundly lunate, lip white, expanded and reflected; umbilicus reduced to a lateral crack. Based on 25 measured adults [QMMO79361 (1), QMMO79360 (4), QMMO65168 (12), QMMO73014 (8)].

Genitalia. Penis (P) long, tapered with slightly expanded apical bulb; thin sheath (PS) present; internally with a smooth papillate verge (PV), upper walls of penial chamber with 5-6 fleshy, relatively thin longitudinal pilasters (PPL), basally with corrugated, thin and straight pilasters (PP) toward the atrium. Epiphallus (E) with relatively long, thick muscular curved ascending arm enveloped and partially folded within penial sheath, strongly reflexed before giving rise to a thinner, relatively short arm; epiphallus entering penis through a simple pore (EP) situated terminally on verge. Penial retractor muscle (PRM) inserted at the junction of the two arms of the epiphallus adjacent to an epiphallic caecum (EC). Vas deferens (VD) thin, attached to penial sheath with connective tissue; a long, thick, finger-like epiphallic flagellum (EF) present at epiphallus-vas deferens junction, weakly bound to vas deferens. Other structures as for genus and without unusual features. Based on three dissected specimens (QMMO65167, QMMO65168, QMMO73014).

Distribution. Lonesome Section , Expedition NP and environs, SCQ.

Habitat. Vine thicket; living under logs and rocks (Fig. 5B).

Remarks. *Pallidelix lonesome* sp. nov. is distinguished by the combination of very large shell with moderately elevated spire and greatly expanded body whorl, teleoconch sculpture of weak, very crowded zigzag microridgelets and scattered pustules on the early whorls, body whorl with reduced sculpture and prominent growth lines (Fig. 4). *P. grandis* sp. nov. has an even more expanded body whorl with an almost smooth last half body whorl. Anatomically *P. lonesome* is distinguished by having 5-6 fleshy, relatively thin, longitudinal penial pilasters apically that become weakly, obliquely disposed medially before giving rise to thin corrugated pilasters basally (Fig.12B). The simple pilaster arrangement in *P. lonesome* is in contrast to the more complex pattern seen in *P. greenhilli* and *P. expeditiana*. Animal with red mantle.

Pallidelix expeditiana sp. nov.
(Figs 6D-F, 7A, 8, 9A-F, 19B,E,H)

Etymology. For the Expedition Range.

Preferred common name. Expedition Range Woodland Snail.

Material examined. (All south central Queensland).

Holotype. QMMO85324, Expedition Range, summit, 24°38′S, 149°02′E, dense vine thicket, in logs, coll. J. Stanisic, D. Potter, 21.vi.1992. Height of shell 25.46 mm, diameter 29.89mm, h/d 0.852, whorls 5.625.

Paratypes. QMMO44125, 3SC/23A,1SA RC, same data as holotype; QMMO23503, 23SC/33A,16 fragments RC, locality as for holotype, coll. J. Stanisic, D. Potter, J. Chaseling, 23.vi.1989; QMMO85001, 2A SC/ 8A RC, Expedition Range NP, summit on Bauhinia-Rolleston road, 24°37.849′S, 148°00.668′E, sevt, in soil under logs/on ground, coll. J. Stanisic, L. Holcroft, 3.vii.2015.

Other material examined. QMMO85052, 1A SC/1A RC, Nuga Nuga NP, Arcadia valley, north side of Lake Nuga Nuga, 25°17.523′S, 148°56.630′E, sevt, in soil under logs/on ground, coll. J. Stanisic, L. Holcroft, 3.vii.2015; QMMO86512, 1A,1SA RC, Bauhinia, 66.3 km SW at Nugga Nugga Stn, Expedition Ra., 25°05′10″S, 148°56′51″E, brigalow open forest, dead on ground, coll. C. Eddie, A. Harris, 18.viii.2010; QMMO73523, 2A SC/2A RC, Taroom, NW at Mt Aldis, off Mapala-Bauhinia Downs Rd, 24°53′40″S, 149°07′02″E, sevt/*Brachychiton* on basalt, on underside of rocks, coll. C. Eddie, W. McDonald, 1.v.2004; QMMO56193, 3A,2SA RC, NW at Presho SF50, 25°10′38″S, 149°03′25″E, brigalow open forest

with vine thicket understorey, under logs, coll. C. Eddie, C. James, F. Carter, 10.ix.1995; QMMO56198, 2A RC, NW at Presho SF50, at Zamia Ck, 25°10′23″S, 149°03′20″E, open eucalypt forest, under logs, coll. C. Eddie, C. James, F. Carter, 9.ix.1995; QMMO86503, 8A,1SA RC, Expedition NP, Amphitheatre Section, SE of Cannondale Mtn, 25°14′00″S, 148°59′49″E, sevt, under rocks and logs, coll. C. Eddie, 25.ix.2002; QMMO65308, 1A SC/15A RC, Taroom, NW at Expedition NP, Amphitheatre Section, 25°12′29″S, 148°59′25″E, sevt, in soil under log, coll. C. Eddie, R. Campbell, 26.v.1998; QMMO66566, Taroom, NW at Expedition NP, Amphitheatre Section, 25°11′44″S, 148°02′41″E, open woodland, coll. C. Eddie, S. Peck, 18.iii.1999; QMMO65322, 5A RC, Taroom, NW at Expedition NP, Amphitheatre Section, 25°12′26″S, 148°59′33″E, sevt, dead on ground, coll. C. Eddie, R. Campbell, 28.v.1998; QMMO79362, 9A RC, NW Taroom, Palmgrove NP, at Bakers Gully, 24°58′37″S, 149°17′23″E, sevt, in soil under logs, coll. C. Eddie, W. Mc Donald, 18.viii.2004; QMMO86527, 9A RC, NW Taroom, Palmgrove NP, at Bakers Gully, 24°58′31″S, 149°17′27″E, sevt/*Brachychiton*, among leaf litter/under and inside logs, coll. C. Eddie, W. Mc Donald, 18.viii.2004; QMMO73019, 3A SC/2A RC, NW Taroom, Palmgrove NP, at Middle Ck, 24°59′05″S, 149°13′28″E, sevt/*Brachychiton*, in soil under fallen bark and logs, coll. C. Eddie, 13.xii.2000; QMMO80672, 2A RC, Injune, c. 71.8 km NE at Sunnyholt Stn, Expedition Range, 25°17′31.3″S, 148°56′37.4″E, eucalypt woodland on sandstone plateau, under logs, coll. C. Eddie, D. Chemello, 13.x.2012; QMMO86508, 2A RC, Injune, c. 72.2 km NE at Sunnyholt Stn, Expedition Range, 25°17′11″S, 148°56′39″E, sevt on slope of sandstone ridge, dead on ground, coll. C. Eddie, 12.x.2012; QMMO60870, 4A,2SA RC, Robinson Ck, opp. Lake Murphy, NW Taroom, 25°29′16″S, 149°39′45″E, eucalypt/*Livistona*, under logs , coll. J. Stanisic, G. Ingram, 6.ii.1997; QMMO60868 9A RC, NW Taroom, on Expedition Range Rd, 25°29′37″S, 149°43′30″E, palm/coolabah swamp, under logs, coll. J. Stanisic, G. Ingram, 6.ii.1997; QMMO60796, 2A SC/2A,4SA RC, Taroom, ENE, Cabbage Tree Ck, 25°27′00″S, 150°10′10″E, *Livistona*/eucalypts/*Ficus*, on creek bank under logs, coll. J. Stanisic. G. Ingram, H. Janetzki, 20.vi.1996; QMMO85268, IA RC, QMMO85269, 1A RC, Taroom, 86.5 km NW at Expedition NP, track on ridgeline W of Old Bore Rd, 25°12′48″S, 149°04′42″E, Ironbark/budgeroo shubby woodland on sandstone, in soil under log, coll. C. Eddies, F. Carter, 23.ix.2002; QMMO85267, 2A RC, Taroom, 71 km NW at Expedition NP, Shepherds Peak trail, 25°18′46″S, 149°11′31″E, eucalypt woodland, on ground under logs, coll. C. Eddie, F. Carter, 25.ix.2001; QMMO60884. 1A,1SA SC/3A,5SA RC, Taroom, NW on Expedition Range Rd at Glenleigh Stn, sevt, under logs, 25°24′13″S, 149°27′49″E, coll. J. Stanisic, G. Ingram, 5.ii.1997; QMMO44154, 4A SC/6A,7SA RC, c. 58 km NW Taroom, on Glenhaughton Rd, 25°24.49′S, 149°29.17′E, sevt/*Brachychiton*, under logs, coll. J. Stanisic, D. Potter, 23.vi.1992; QMMO79423, 1A SC, NW Taroom, Comely Holding, via Glenhaughton-Mapala Rd, 24°06′51″S, 149°04′00″E, sevt along watercourse, inside log, coll. C. Eddie, W. McDonald, 19.viii.2004; QMMO80667, 8A,3SA RC, Injune, 42.9 km NE at Kentucky Stn, 25°34′20.8″S, 148°52′29.7″E, sevt/steep sandstone ridge slope, dead on ground and in cavities among boulders, coll. C. Eddie, A Harris, 12.v.2010; QMMO80668, 3A,1SA RC, Injune, 46.3 km NE at Kentucky Stn, 25°32′01.9″S, 148°52′39.4″E, sevt/ sandstone ridge slope in narrow valley, dead on ground and in cavities among boulders, coll. C. Eddie, A Harris, 13.v.2010; QMMO80648, 1A,1SA RC, Injune, 42.4km NE at Kentucky Stn, 25°34′13.7″S, 148°51′52.8″E, eucalypt woodland with sevt understorey, on ground, coll. C. Eddie, A. Harris,12.v.2010; QMMO73025, 1SA SC, Expedition NP, Beilba Section, 25°35′00″S, 148°58′38″E, under rock, coll. C. Eddie, 12.ix.2001; QMMO80666, 1A SC/1A RC, Injune, 41 km NE at Waddy Brae Stn, 25°38′32.4″S, 148°54′53.7″E, sevt/sandstone ridge slope, live under rock, coll. C. Eddie, R. Johnson, R. Aisthorpe, E. Mulholland, 31.iii.2015; QMMO65355, 1A SC, NE at Waddy Brae Stn, 25°38′55″S, 148°55′40″E, sevt/edge of cliff above Bottle Tree Gully, coll. C. Eddie, D Johnson, 3.ix.1997; QMMO85446, 2A RC, Injune, 43.8 km NE at Waddy Brae Stn, 25°36′07.5″S, 148°54′52.7″E, sevt/sandstone gorge, dead on ground, coll. R. Aisthorpe, A. Bendall, 14.ix.2015; QMMO80649, 2A RC, Injune, 51km ENE at Fairview Holding, 25°40′04″S, 149°02′24″E, eucalypt woodland with sevt understorey, in litter among fig roots and boulders, coll. C. Eddie, A. Bendall, 18.xii.2013; QMMO80650, 1A RC, Injune, 50.5km NE at Fairview Holding, 25°35′25″S, 148°59′10″E, eucalypt woodland, dead on ground beside boulders, coll. C. Eddie,11.iv.2012; QMMO85290, 9A/1SA RC, Injune, 46.4 km NE at Fairview Holding, 25°39′10.7″S, 148°58′48.4″E, sevt on sandstone slope, dead on ground and under/among rocks, coll. C. Eddie,19. vi.2006; QMMO85296, 4A SC/2A RC, Injune, 46.2 km NE at Fairview Holding, 25°38′45.3″S, 148°58′28.3″E, sevt on sandstone slope, inside logs and under rocks, coll. C. Eddie, A. Bendall, 14.vii.2015; QMMO80653, 16A RC, Injune, 51.4 km E at Springwater Stn, 25°40′45.7″S, 149°02′48.7″E, sevt on sandstone ridge slope, dead on ground and under rocks, coll. C. Eddie, 21.vi.2011; QMMO80652, 16A RC, Injune, 44.6 km E at Springwater Stn, 25°43′15.6″S, 148°59′32.7″E, sevt on sandstone ridge slope, dead on ground and under rocks, coll. C. Eddie, 17.v.2011; QMMO86522, 3A,2SA RC, Injune, 41.9 km E at Springwater Stn, 25°42′04.4″S, 148°57′14.6″E, sevt on sandstone ridge slope, dead on ground and under rocks/on top of fallen tree, coll. C. Eddie, 12.v.2011; QMMO86519, 8A,3SA RC, Injune c. 31.1 km WNW at at Oakwells Stn, 25°44′58″S, 148°16′35″E, sevt on scree/steep basalt ridge slope, under and among rocks, coll. C. Eddie, B. Cosh, 5.iv.2001; QMMO86520, 7A,4SA RC, Injune c. 29.9 km WNW at Oakwells Stn, 25°45′04″S, 148°17′12″E,

sevt with emergent *Brachychiton* on scree/basalt ridge slope, under and among rocks, coll. C. Eddie, B. Cosh, 5.iv.2001; QMMO86521, 3A,1SA RC, Injune c. 30.2 km WNW at at Oakwells Stn, 25°44′56″S, 148°17′02″E, sevt /basalt ridge slope, under and among rocks, coll. C. Eddie, B. Cosh, 5.iv.2001; QMMO71473, 1A RC, Injune c. 29.9 km WNW at at Oakwells Stn, 25°45′S, 148°17′E, sevt, alt. 800 m, coll. G. Monteith, D. Cook, 7.iii.2002; QMMO73521, 1A RC, Injune at Crowman Stn, 25°51′21″S, 148°16′22″E , sevt with *Brachychiton* on basalt scree, on underside of rock. Coll. C. Eddie, W McDonald, 25.iv.2004; QMMO85473, 5A,1SA RC, Injune c. 29.5 km W at Crowman Stn, 25°50′15.5″S, 148°16′25.9″E, sevt with emergent *Casuarina* /NE facing basalt ridge slope, in leaf litter among rocks, coll. C. Eddie, W. McDonald, 25.iv.2004; QMMO80669, 4A,1SA RC, Injune c. 25.5 km W at Cobbadah Stn, 25°50′28″S, 148°18′50″E, sevt on basalt scree slope, in leaf litter around fig roots and among rocks, coll. C. Eddie, 10.ix.2009; QMMO80658, 4A,1SA RC, Injune c. 25.5 km W at Cobbadah Stn in Mt Hutton Range, 25°50′12″S, 148°19′53″E, eucalypt woodland with sevt understorey/steep basalt ridge slope, coll. C. Eddie, 11.ix.2009.

Other material. Mt Aldis: QMMO85484, 1A RC; QMMO79421, 1A RC. NW Taroom, beside Robinson Ck: QMMO65431, 3A SC/2A RC; QMMO65441, 2A,1SA SC/1A RC; QMMO65445, 1A SC/1A RC;QMMO65435, 4A,1SA RC. NW Taroom, at Lake Murphy: QMMO60791, 1SA SC/1A,5SA RC; QMMO79446, 1SA RC. NW Taroom at Glenhaughton Stn: QMMO86539, 1A SC. NW Taroom at Palmgrove NP: QMMO85276, 2A RC; QMMO85275, 1A RC; QMMO52517, 6A RC; QMMO86529, 1A,1SA RC; QMMO85273, 3A,1SA RC; QMMO73315, 3A RC; QMMO66572, 3A RC; QMMO66565, 1A SC. Injune E at Fairview Stn: QMMO85294, 3A RC. Injune E at Springwater Stn: QMMO80665, 1A RC; QMMO85288, 4A,1SA RC; QMMO85285, 2A RC; QMMO85286, 3A,1SA RC. Expedition NP, Amphitheatre Section: QMMO73028, 1A SC; QMMO65298, 1SA SC; QMMO65308, 1SA SC; QMMO67035, 2A RC; QMMO65310, 2A SC/6A,1SA RC; QMMO86504, 5A RC; QMMO86506, 1A RC; QMMO85270, 2A RC; QMMO66570, 1A RC; QMMO85271, 1SA RC; QMMO86507, 1SA RC; QMMO65289; Injune WNW at Oakwells Stn: QMMO66508, 1A,4SA RC; Injune W at Crowman Stn: QMMO85475, 2A,1SA RC.

Diagnosis. Shell large, subglobose, brown to dark brown spire, occasionally with a pinkish tinge and generally with a reddish brown subsutural band, yellowish-brown to brown base; teleoconch sculpture consisting of oblique to zigzag irregular microridgelets and coarse scattered pustules on the early whorls, pustules becoming more pronounced on the penultimate and body whorls. Upper walls of penial chamber with 4-5 thick, simple and occasionally anastomosing, fleshy longitudinal pilasters (PPL) that become obliquely disposed medially before straightening basally.

Description. Shell large, subglobose, brown to dark brown spire, occasionally with a pinkish tinge, weak reddish brown subsutural band present, sometimes absent, yellowish-brown to brown base, spire moderately elevated; whorls 5.5-6.0 (mean 5.625), evenly rounded the last descending rapidly in front (Fig. 6D-F). Height of shell 18.31-25.20 mm (mean 21.71 mm), diameter 24.10-29.64 mm (mean 26.61 mm), h/d 0.750-0.904 (mean 0.830). Protoconch as for genus. Teleoconch sculpture consisting of oblique to zigzag irregular microridgelets and coarse scattered pustules on the early whorls, pustules becoming more pronounced on the penultimate and body whorls (Fig. 7A); base shiny and smooth. Aperture roundly lunate with a pink interior, lip white, expanded and reflected; umbilicus reduced to a lateral crack. Based on 56 measured adults [QMMO86527 (9), QMMO85052 (1), QMMO79362 (9), QMMO65308 (14), QMMO44125 (23)].

Genitalia. (Fig. 8) Penis (P) long, tapered with slightly expanded apical bulb; thin sheath (PS) present; internally with a smooth papillate verge (PV), upper walls of penial chamber with 4-5 thick, simple and anastomosing, fleshy longitudinal pilasters (PPL) that become thinner, obliquely disposed medially before straightening basally (PP) (Fig. 9A). Epiphallus (E) with relatively long, thick muscular curved ascending arm enveloped and partially folded within penial sheath, strongly reflexed and slightly twisted before giving rise to a thinner, relatively short arm; epiphallus entering penis through a simple pore (EP) situated terminally on verge. Penial retractor muscle (PRM) inserted at the fold of the two arms of the epiphallus adjacent to an epiphallic caecum (EC). Vas deferens (VD) thin, attached to penial sheath with connective tissue; a relatively long, thick, finger-like epiphallic flagellum (EF) present at epiphallus-vas deferens junction, bound to vas deferens. Vagina (V) equal to length of penis. Atrium (Y) simple. Free oviduct (UV) shorter than vagina; bursa copulatrix (S) simple, situated

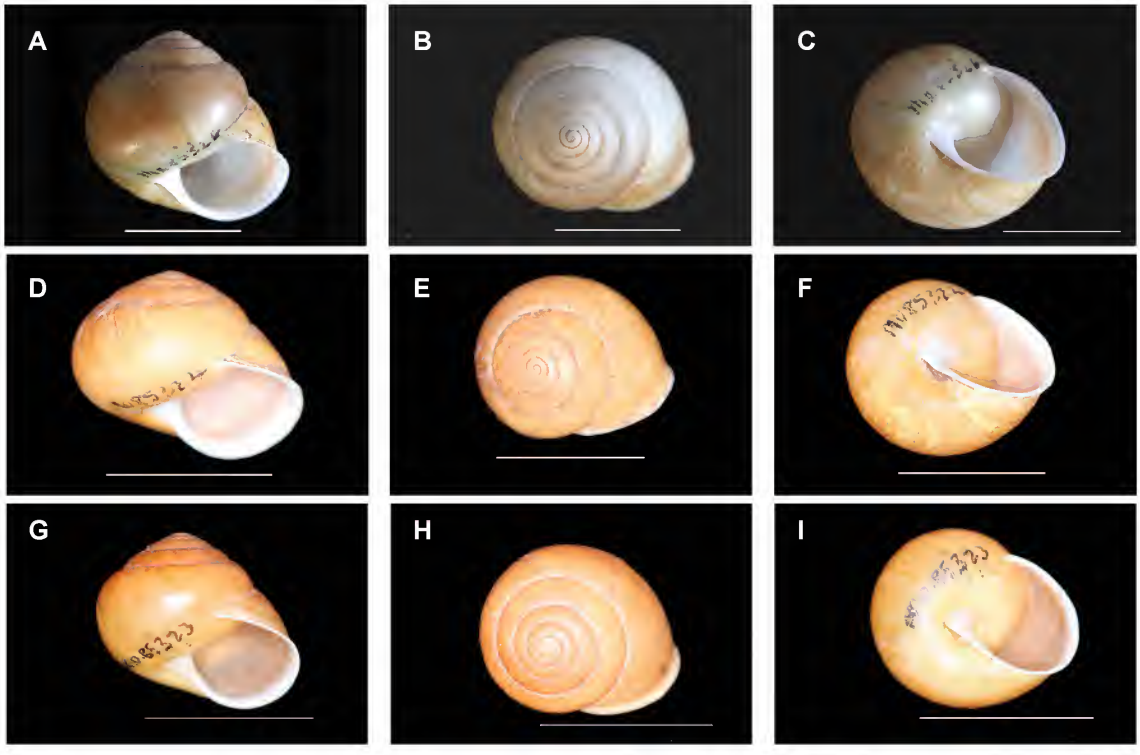

FIG.6. *Pallidelix* holotypes. **A-C**, *P. lonesome* sp. nov., QMMO85326; **D-F**, *P. expeditiana* sp. nov., QMMO85324; **G-I**, *P. potteri* sp.nov., QMMO85323. Scale bars = 20 mm.

at the base of the albumen gland (GG) with a slender stalk (SS); prostate (DG), uterus (UT) and hermaphroditic duct (GD) without unusual features. Based on five dissected specimens (QMMO44125, QMMO79417, QMMO66566, QMMO60796, QMMO80666).

Distribution. Expedition Range NP, including Palmgrove NP and Nuga Nuga NP but excluding the Lonesome Section and Expedition Resource Reserve, SCQ. Possible outliers in the Great Dividing Range, west of Injune, SCQ.

Habitat. Vine thickets; living under and inside logs (Fig. 5C-F).

Remarks. *Pallidelix expeditiana* sp. nov. is the most widespread of the species covered in this revision and inhabits a large area of the Expedition Range from east of Injune and north-west of Taroom to the summit of the range on the Dawson Highway (Bauhinia-Rolleston Road). The penial pilaster configuration of 4-5 thick, apical, fleshy longitudinal pilasters that sometimes anastomose and become thin and slightly oblique medially before straightening toward the atrium, coupled with the pattern of zigzag irregular microridgelets and coarse scattered pustules on the early whorls with pustules becoming more pronounced on the penultimate and body whorls are considered key distinguishing features (FIGS 7A, 9A). Molecular studies may yet prove otherwise. *P. expeditiana* is distinguished from *P. greenhilli* (Cox, 1866) by the coarser telecoconch sculpture and less complex penial pilaster pattern.

The populations of *P. expeditiana* occur in scattered patches of vine thicket of variable quality ranging from relatively dense bottle tree scrubs to drier vine dominated scrub. Rainfall in the Expedition Range is locally variable

FIG. 7. *Pallidelix* shell sculpture. **A**, *P.expeditana* sp. nov., QMMO44125; **B**, *P. potteri* sp. nov., QMMO46301; **C**, *P. staricki* sp. nov., QMMO79085; **D**, *P. lambkinae* sp. nov., QMMO73020; **E**, *P. moffatt* sp. nov., QMMO85048; **F**, *P.minerva* sp. nov., QMMO56625.

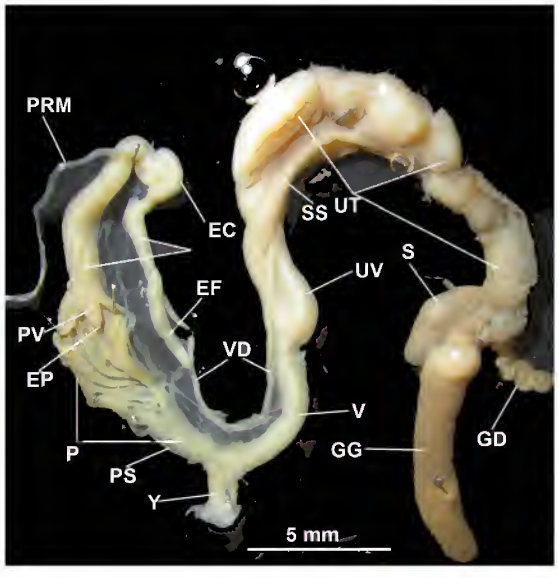

FIG. 8. Genitalia, *Pallidelix expeditiana* sp. nov., Palmgrove NP, SCQ , QMMO79147.

reflecting topography and not surprisingly the shells exhibit significant size differences across the species' range. Largest specimens come from the northern part of the range (summit) with the smallest being the more southwestern Amphitheatre populations. Dissection of limited adult material across the species' range showed some variability in penial pilaster pattern that may indicate incipient speciation in isolated and distant populations (Fig. 9B-F). Molecular studies based on a wider range of material may be needed to fully resolve the integrity of this species. Animal with red mantle.

Specimens from Oakwells, Crowman and Cobbadah Stations (localities in the Great Dividing Range and to the west of the Expedition Range) are included in *P. expeditiana* on the basis of shared conchological features (teleoconch with oblique to zigzag microridgelets and prominent pustules) in the absence of spirit material for study of reproductive structures.

Pallidelix potteri sp. nov.
(Figs 6G-I, 7B, 12C, 19C)

Etymology. For Darryl Potter, Collection Manager for Molluscs, Queensland Museum.

Preferred common name. Potter's Woodland Snail.

Material examined. (All mid-central Queensland).

Holotype. QMMO85323, banks of Charlevue Ck, on Blackdown Tableland Rd, 23°39.5'S, 149°09.4'E, vine thicket, inside logs and trees, coll. J. Stanisic, D. Potter, 20.vi.1992. Height of shell 25.27 mm, diameter 28.13 mm, h/d 0.898, whorls 6.125.

Paratypes. QMMO44111, 7SC/2RC, same data as holotype; QMMO46301, 3SC/2RC, Charlevue Ck, on Blackdown Tbld Rd, 23°39.5'S, 149°09.4'E, riverine thicket, in logs, coll. J. Stanisic, D. Potter, 17.v.1993.

Other material examined. QMMO64443, 1SA RC, Blackdown Tbld NP, Rainbow Falls walk, 23°49'S, 149°05'E, C. Hoskins, 11.i.1998; QMMO23486 3A/3SA RC, 1SA SC, c.3.9 km along loop road from southern turnoff, Blackdown Tbld NP, 23°48'S, 149°01'E, tall moist eucalypt forest, on ground, coll. J. Stanisic, D. Potter, J. Chaseling, 24.vi.1989; QMMO23496 1SA RC/1A 11SA SC, Blackdown Tbld Rd, c.11.4 km SW Capricorn Hwy, 23°39'S, 149°09'E, remnant thicket, under and in logs, coll. J. Stanisic, D. Potter, J. Chaseling, 24.vi.1989; QMMO9974, 1SA SC/1A RC, Blackdown Tbld, ca 150 km W of Rockhampton, 23°39'S, 149°09'E, open forest on sandstone, coll. R Raven, G. Monteith, 6.ii.1981; QMMO44102, 2A/5SA RC, slopes of peak, c.11.7 km E of Comet, Comet-Blackwater Rd, 23°36'S, 148°39.5'E, vine thicket, under logs in soil, coll. J. Stanisic, D. Potter, 20.vi.1992.

Diagnosis. Shell medium-sized to large, subglobose, dark brown spire with shiny, demarcated yellowish green base; upper surface of teleoconch with very fine and dense pustules on early whorls, prominent oblique to zigzag microridgelets and reduced pustules on the latter whorls, microridgelets becoming more pronounced on the body whorl. Upper walls of penial chamber with 6-7 thick, simple and straight, fleshy longitudinal pilasters (PPL) becoming obliquely disposed medially and thinner basally.

Description. Shell medium-sized to large, subglobose, dull, dark brown spire with shiny, demarcated yellowish green base; spire moderately elevated, whorls 5.125-5.875 mm (mean 5.500 mm), evenly rounded, the last descending rapidly in front (Fig. 6G-I). Height of shell 17.59-23.52 mm (mean 20.22 mm), diameter 21.18-26.10 mm (mean 24.51 mm), h/d 0.770-0.903 (mean 0.824). Protoconch as for genus. Teleoconch with very fine and dense pustules on early whorls, prominent oblique to zigzag

FIG. 9. Penial pilaster patterns in populations of *Pallidelix expeditana* sp. nov. **A**, Summit, Expedition Ra., QMMO44125; **B**, Waddy Brae Stn, QMMO80666; **C**, Cabbage Tree Ck, QMMO60796; **D**, Amphitheatre, QMMO66566; **E**, Palmgrove NP, QMMO79147; **F**, Fairview Stn, QMMO85181. All SCQ. Scale of images B-F as for A.

microridgelets and reduced pustules on the latter whorls, microridgelets becoming more pronounced on the penultimate and body whorls (Fig. 12C); base shiny and smooth. Aperture roundly lunate, lip white, expanded and reflected; umbilicus reduced to a lateral crack. Based on 8 measured adults [QMMO44111 (2), QMMO46301 (2), QMMO9974 (1), QMMO23486 (3)].

Genitalia. Penis (P) long, tapered with slightly expanded apical bulb; thin sheath (PS) present;

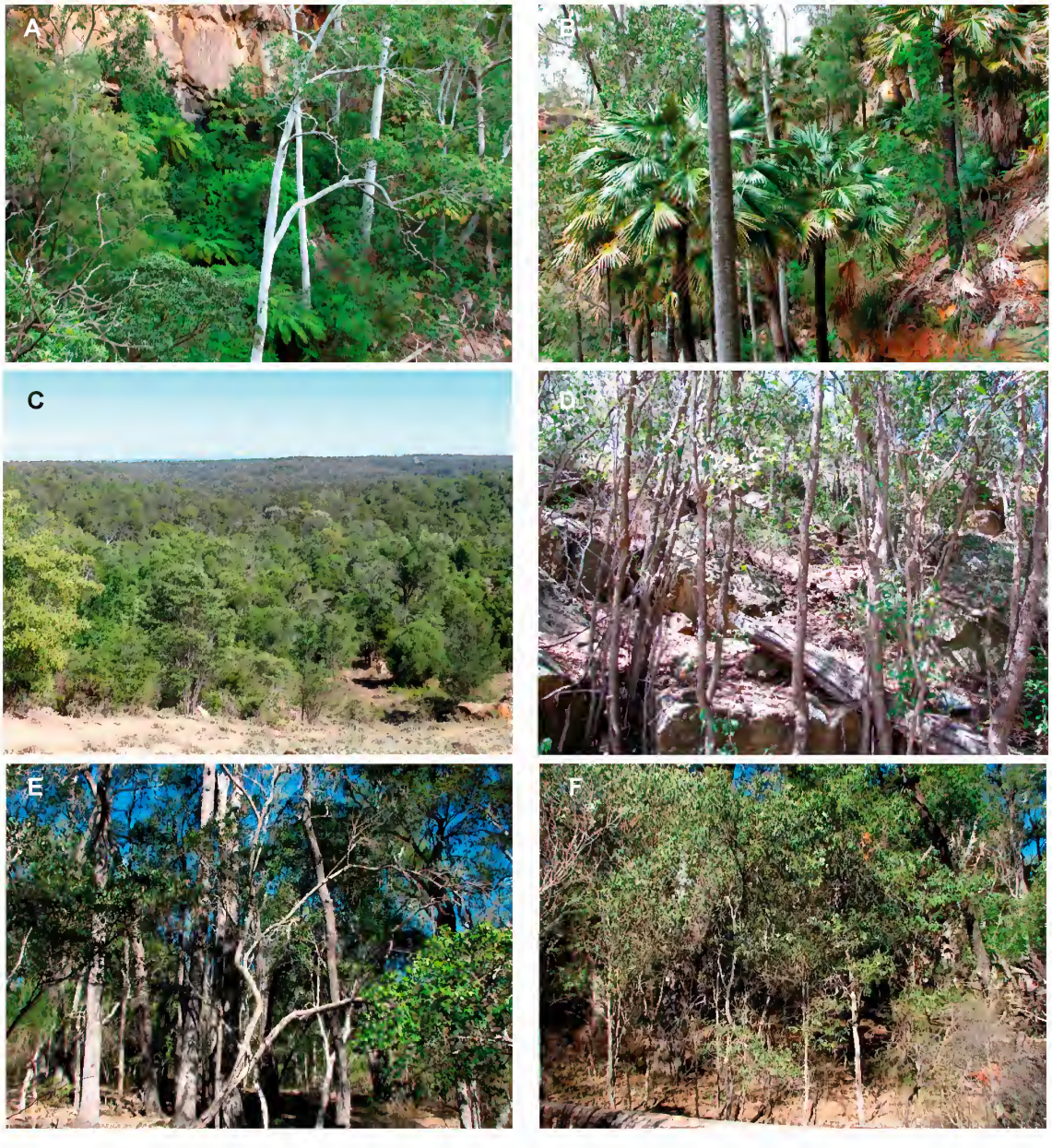

FIG. 10. *Pallidelix* habitats. **A-B**, *P. potteri* sp. nov: Blackdown Tableland, MCQ; **C-D**, *P. staricki* sp. nov: Nuggett Hills, SCQ; **E-F**, *P. lambkinae* sp. nov: Stones Country Resource Reserve, SCQ. Images: C. Eddie.

internally with a smooth papillate verge (PV), upper walls of penial chamber with 6-7 thick, simple and straight, fleshy longitudinal pilasters (PPL) that beome obliquely disposed medially and thinner basally (PP) (Fig. 7B). Epiphallus (E) with relatively long, thick muscular curved ascending arm enveloped and partially folded within penial sheath, strongly reflexed and slightly coiled before giving rise to a thinner, relatively short arm; epiphallus entering penis through a simple pore (EP) situated terminally on verge. Penial retractor muscle inserted at the fold of the two arms of the epiphallus adjacent to an epiphallic caecum (EC). Vas deferens (VD) thin, attached to penial sheath with connective tissue; a relatively long, thick epiphallic flagellum (EF) present at epiphallus-vas deferens junction, bound to vas deferens. Other structures as for genus and without unusual features. Based on two dissected specimens [(QMMO46301 (1), QMMO23496 (1)].

Distribution. Blackdown Tableland and surrounding areas to the north, MCQ.

Habitat. Moist eucalypt/palm forest and vine thicket; living under and inside logs (Fig. 10A, B).

Remarks. *Pallidelix potteri* sp. nov. differs from *P. expeditiana* sp. nov. by the combination of teleoconch with fine pustulations and very prominent microridgelets (Fig. 7B) and penial chamber with 6-7 well defined, thick, straight and simple, apical longitudinal pilasters (Fig. 12C). In contrast *P. expeditiana* has a teleoconch with much coarser microridgelets and pustulation (Fig. 7A), and a penial chamber with 4-5, sometimes anastomosing, apical pilasters (Fig. 9A).

Pallidelix potteri sp. nov. occurs at the convergence of three sandstone ranges that form Blackdown Tableland, and the adjacent plains to the north. Much of the landscape on the plains has been transformed into farming and grazing land that has reduced areas of natural vegetation significantly. In spite of this *P. potteri* has managed to survive in thicket long drainage lines such as Charlevue Creek and in other remnant patches of vine thicket (peak E of Comet). However, the relatively untouched Blackdown Tableland remains the core area for the species where it lives in wet eucalypt and palm forest. Animal with reddish mantle.

Pallidelix staricki sp. nov.
(Figs 7C, 11A-C, 12D, 19G)

Etymology. For entomologist Noel Starick.

Preferred common name. Starick's Woodland Snail.

Material examined. (All south central Queensland).

Holotype. QMMO86538, Roma, c. 75 km NE at Spring Gully Stn, 25°56′08″S, 149°03′23″E, sevt in sandstone gully, under logs and rocks, coll. C. Eddie, 15.v.2009. Height of shell 17.83 mm, diameter 23.91 mm, h/d 0.746, whorls 5.375.

Paratypes. QMMO86516, 5A,1SA RC, same data as holotype; QMMO79085, 1A SC/5A,4SA RC, Spring Gully , c. 76.1 km NE of Roma, 25°56′07″S, 149°03′23″E, woodland, under rocks and logs, coll. C. Eddie, 15.v.2009.

Other material examined. QMMO85465, 11A,12SA RC, Injune, 55.7 km E at Nuggett Hills Stn, 25°56′53.7″S, 149°06′40.1″E, sevt/sandstone ridge slope, in leaf litter among rocks/under logs, coll. C. Eddie, 5.viii.2016; QMMO80670, 26A,6SA RC, Injune, 55 km E at Nuggett Hills Stn, 25°57′21.1″S, 149°06′15.5″E, sevt in gully between sandstone ridge, dead on ground and under rocks/logs, coll. C. Eddie, A. Bendall, 16.i.2014; QMMO85257, 2A RC, 60.3 km E at Nuggett Hills Stn, beside Eurombah Ck, 25°59′03″S, 149°08′55″E, eucalypt woodland with sevt understorey/sandstone, in leaf litter among rocks/boulders, coll, C. Eddie, 2.i.2017; QMMO80664, 1A,4SA RC, Injune 43.7 km ESE at Scotts Creek Stn, 25°53′37″S, 149°00′01″E, sevt in gully/sandstone, under rocks and at basses of trees, coll. C. Eddie, 26.v.2009; QMMO86518, 2A,3SA RC, Injune c. 64.4 km ESE at Strathblane Stn, Knob Paddock, 25°54′39″S, 149°12′23″E, sevt at head of gully along sandstone range, in leaf litter among rocks and logs. Coll. C. Eddie, 4.vii.2008.

Diagnosis. Shell large, subglobose, dark brown spire with yellowish green base and a weak reddish brown subsutural band; teleoconch with prominent, crowded, oblique to zigzag microridgelets, persisting on the last part of the body whorl and very weak pustulation. Upper walls of penial chamber with 4 thick, fleshy longitudinal pilasters extending to the atrium.

Description. Shell large, subglobose, dark brown spire with a yellowish green base and a reddish brown subsutural band, spire moderately

elevated, whorls 5.125-6.0 mm (mean 5.500) evenly rounded the last descending rapidly in front (Fig. 11A-C). Height of shell 16.19-23.89 mm (mean 19.01 mm), diameter 22.34-28.52 mm (mean 24.55 mm), h/d 0.725-0.840 (mean 0.773). Protoconch as for genus. Teleoconch with prominent and crowded, oblique to zigzag microridgelets persisting on the last part of the body whorl, pustules barely visible (Fig. 7C); base shiny and smooth. Aperture roundly lunate, lip white, expanded and reflected; umbilicus reduced to a lateral crack. Based on 35 measured adults [QMMO86516 (5), QMMO79085 (4), QMMO80670 (26)].

Genitalia. Penis (P) tapered with thin sheath (PS); internally with a smooth papillate verge (PV), upper walls of penial chamber with 4 thick, fleshy longitudinal pilasters (PPL) extending to the atrium (Fig. 12D). Epiphallus (E) with relatively long, thick muscular curved ascending arm enveloped and partially folded within penial sheath, strongly reflexed and slightly twisted before giving rise to a thinner, relatively short arm; epiphallus entering penis through a simple pore (EP) situated terminally on verge. Penial retractor muscle inserted at the fold of the two arms of the epiphallus adjacent to an epiphallic caecum .Vas deferens (VD) thin, attached to penial sheath with connective tissue; a relatively short, thick finger-like epiphallic flagellum (EF) present at epiphallus-vas deferens junction, bound to vas deferens. Other structures as for genus and without unusual features. Based on one dissected specimen (QMMO79085).

Distribution. Spring Gully and Nuggett Hills Stations and environs, SCQ.

Habitat. Vine thicket; living under rocks and logs (Fig. 10C, D).

Remarks. *Pallidelix staricki* sp. nov. differs from *P. expeditiana* sp. nov. in having a teleoconch with very prominent, oblique to zigzag microridgelets and very reduced pustulation (Fig. 7C), and a penial chamber that has fewer straight longitudinal pilasters extending to the atrium (Fig. 12D). In contrast, the shell of *P. expeditiana* has scattered fine to coarse pustulation with weaker microridgelets (Fig. 7A) and a penis with 4-5 apical longitudinal penial pilasters that become obliquely disposed medially before straightening basally (Fig. 9A). In the absence of material for dissection, specimens other than those from Spring Gully Stn are included here on the basis of general conchological similarity and geographic proximity. Their status will need to be confirmed either by reproductive morphology or molecular studies. Animal with bright red mantle.

Pallidelix lambkinae sp. nov.
(Figs 7D, 11D-F, 12E, 13, 19F)

Etymology. For Queensland Museum entomologist Christine Lambkin.

Preferred common name. Lambkin's Woodland Snail.

Material examined. (All south central Queensland).

Holotype. QMMO86523, Miles, 42.5km NW at Stones Country Resource Reserve, 26°23′23″S, 149°52′47″E, sevt, inside log, coll. C. Eddie, 22.x.2016. Height of shell 20.48 mm, diameter 26.75 mm, h/d 0.898, whorls 5.625. [animal SC].

Paratypes. QMMO79086, 3A SC/5A,1SA RC, at Stones Country Resource Reserve via Gurulmundi Rd, c.42.5km NW of Miles, 26°23′21″S, 149°52′56″E, sevt/ooline/figs, inside log, coll. C. Eddie, 28.viii.2009; QMMO73020, 2A SC/1A RC, Miles, NW at Stones Country Resource Reserve, 26°23′24″S, 149°52′50″E, sevt, under logs, coll. C.Eddie, 30.vi.2003; QMMO79453, 2A RC, Stones Country Resource Reserve, Gurulmundi, 26°23′24″S, 149°52′50″E, sevt/ooline, under logs, coll. C.Eddie, 30.vi.2003; QMMO56194, 3A,1SA RC, Miles, NW at Gurulmundi SF, 26°23′35″S, 149°53′18″E, sevt, on ground, coll. C. Eddie, 11.ix.1995; QMMO79123, 8A, 8SA RC, Gurulmundi SF, c. 40.4 km NW of Miles, 26°23′49″S, 149°54′25″E, sevt, coll. S. Bell, 13.ix.2009.

Other material examined. QMMO79147, 1A SC/6SA RC, Miles, c.44.7 km NW, 26°23′34″S, 149°54′25″E, woodland, under logs, coll. G. Jones, 27.viii.2009; QMMO79220, 3A SC/1A,3SA RC, Miles, c.44.3 km NW, 26°23′56″S, 149°50′25″E, woodland, under logs, coll. G. Jones, 27.viii.2009; QMMO79080,2A,5SA SC/1A,1SA RC, Miles, c.43.9 km NW, 26°23′42″S, 149°51′15″E, , under logs, coll. G. Jones, 27.viii.2009; QMMO79213,1A SC/ 3SA RC, Miles, c.42.5 km NW, 26°24′30″S, 149°51′19″E, , ironbark woodland, under logs, coll. G. Jones, 25.viii.2009

Diagnosis. Shell medium-sized (10-20 mm) to large, subglobose, dark brown spire with yellowish green base and a weak reddish brown subsutural band, teleoconch with prominent,

crowded, oblique to zigzag microridgelets persisting on the last part of the body whorl with very reduced pustulation. Penis with 4-5 thick, fleshy longitudinal pilasters apically becoming thin near the atrium.

Description. Shell medium sized to large, subglobose, dark brown spire with yellowish green base and a weak reddish brown subsutural band, spire moderately elevated, whorls 5.375-5.750 (mean 5.500) evenly rounded the last descending rapidly in front (Fig. 11D-F). Height of shell 18.22-21.89 mm (mean 20.05 mm), diameter 23.93-29.18 mm (mean 26.40 mm), h/d 0.717-0.785 (mean 0.759). Protoconch as for genus. Teleoconch with prominent, crowded oblique to zigzag microridgelets persisting on the last part of the body whorl, pustules barely visible (Fig. 7D); base shiny and smooth. Aperture roundly lunate, lip white, expanded and reflected; umbilicus reduced to a lateral crack. Based on 15 measured adults [QMMO73020 (1), QMMO79086 (1), QMMO79453 (2), QMMO56194 (3), QMMO79123 (8)].

Genitalia. (Fig. 13) Penis (P) long, tapered with thin sheath (PS); internally with a smooth papillate verge (PV), upper walls of penial chamber with 5-6 thick, longitudinal pilasters (PPL) occupying top half of the penial chamber, becoming thin near the atrium (PP), background pattern of fine pustules (Fig. 12E). Epiphallus (E) with relatively long, thick muscular curved ascending arm enveloped and partially folded within penial sheath, strongly reflexed and slightly coiled before giving rise to a thinner, relatively short arm; epiphallus entering penis through a simple pore (EP) situated terminally on verge. Penial retractor muscle inserted at the fold of the two arms of the epiphallus adjacent to an epiphallic caecum.Vas deferens (VD) thin, attached to penial sheath with connective tissue; a relatively short, thick finger-like epiphallic flagellum (EF) present at epiphallus-vas deferens junction, bound to vas deferens. Vagina (V) equal to length of penis. Atrium (Y) simple. Free oviduct (UV) shorter than vagina; bursa copulatrix (S) simple, situated at the base of the albumen gland (GG) with a slender stalk (SS); prostate (DG), uterus (UT) and hermaphroditic duct (GD) without unusual features. Based on two dissected specimens (QMMO73020, QMMO86523).

Distribution. Gurulmundi State Forest and environs, SCQ.

Habitat. Vine thicket; living under logs (Fig. 10E-F).

Remarks. *Pallidelix lambkinae* sp. nov. is most similar to *P. staricki* sp. nov. in having a teleoconch with very prominent oblique to zigzag microridgelets and very reduced pustulation (Fig. 7D). However, the pattern of microridgelet sculpture in *P. lambkinae* is coarser than that of *P. staricki* (Fig. 7C). Internally the penis has a greater number of straight longitudinal pilasters and a pustular background (cf. Fig. 12D, E). *P. lambkinae* is only known from the vine thickets of the Gurulmundi SF and is the most southerly species of the genus. Animal with bright red mantle.

Pallidelix moffatt sp. nov.
(Figs 7E, 11G-I, 12F)

Preferred common name. Mt Moffatt Woodland Snail.

Material examined. (All south central Queensland).

Holotype. QMMO86537, Carnarvon NP, Mt Moffatt Section, Top Shelter Shed, 24°54′50.6″S, 148°01′32.4″E, burnt eucalypt woodland, under rocks and logs, coll. J. Stanisic, L. Holcroft, 24.ix.2012. Height of shell 22.61 mm, diameter 26.80 mm, h/d 0.844, whorls 5.5.

Paratypes. QMMO80702, 7A RC, Carnarvon NP, Mt Moffatt Section, Top Shelter Shed, 24°54′50.6″S, 148°01′32.4″E, burnt eucalypt woodland, under rocks and logs, coll. J. Stanisic, L. Holcroft, 24.ix.2012; QMMO85048, 1A,1SA SC/22A, 1SA RC, Carnarvon NP, Mt Moffatt Section, Rotary Shelter Shed, 24°54′36.6″S, 148°02′28.6″E, burnt eucalypt woodland, under rocks and logs, coll. J. Stanisic, L. Holcroft, 24.ix.2012.

Other material examined. QMMO66455, 1A RC, Carnarvon NP, Mt Moffatt Section, Racecourse Spring, 24°56′00″S, 148°05′43″E, remnant vine thicket on basalt scree, dead among rocks and under logs, coll. C. Eddie, 22.i.2004; QMMO66499, 1A RC, Carnarvon NP, Mt Moffatt Section, E slope of Mt Moffatt below summit, 25°03′30″S, 148°02′47″E, semi-evergreen vine thicket on basalt, coll. C Eddie, 4.ix.1999; QMMO85483, 5A RC, Carnarvon NP, Mt Moffatt Section, NE Marlong Plain, 24°55′47″S, 147°58′25″E, sevt/ *Brachychiton* in sandstone gully, dead among rocks and under logs, coll. C. Eddie, 22.vii.2004; QMMO23542,

1A,15SA, SC/ 3SA RC, Carnarvon NP, Mt Moffatt Section, head of Carnarvon Ck, 24°57′S, 148°05′E, open woodland, under timber, coll. J. Stanisic, D. Potter, J. Chaseling, 29.vi.1989; QMMO23532, 20SA SC/1A,1SA RC, Carnarvon NP, top of Peawaddy Gorge, 24°55′S, 148°04′E, open eucalypt woodland/ cycads, under timber and rocks, coll. J. Stanisic, D. Potter, J. Chaseling, 29.vi.1989; QMMO85476, 6A,1SA RC, Carnarvon NP, Mt Moffatt Section, on N side of Moffatt Peak, 25°03′24″S, 148°02′41″E, sevt on basalt scree, dead among rocks, coll. C. Eddie, 13.x.2002; QMMO85455, 2A RC, Carnarvon NP, Mt Moffatt Section, headwaters of gully on ridge NW of Lot's Wife, 24°57′24″S, 147°57′00″E, sevt/*Brachychiton*/ *Ficus*, dead on ground, coll. C. Eddie, 4.ii.2000; QMMO80700, 1SA SC/3A RC, Carnarvon NP, Mt Moffatt Section, Mahogany Forest Rd, 24°54′42.3″S, 148°03′04.8″E, burnt eucalypt woodland, under rock in litter, coll. J. Stanisic, L. Holcroft, 24.ix.2012; QMMO85278, 2A RC, Carnarvon NP, Mt Moffatt Section, E side Mt Moffatt Peak, 25°03′31″S, 148°02′47″E, sevt on steep basalt hill slope, dead on ground, coll. C. Eddie, W. Mc Donald, 25.iv.2003; QMMO85451, 1A RC; QMMO85452, 2A RC, Carnarvon NP, Mt Moffatt Section, gully on W side of Gee Gee Gap Rd, 24°56′55″S, 147°54′10″E, sevt with emergent *Brachychiton* spp.in sheltered gully on sandstone between basalt-capped ridges, dead on ground, coll. C. Eddie, W. McDonald, 23.iv.2003; QMMO66491, 1A,1SA RC, Carnarvon NP, Mt Moffatt Section, Kenniffs Cave Rd, 24°53′04″S, 148°00′23″E, woodland, coll. C. Eddie, 20.i.1999; QMMO54026, 1A RC, Carnarvon NP, Mt Moffatt Section, edge of Marlong Plain, 24°56′33″S, 147°57′52″E,tussock grassland, on ground, coll. C. Eddie, 6.x.1995; QMMO85481, 3A,1SA RC, Carnarvon NP, Mt Moffatt Section, NE Marlong Plain, 24°55′37″S, 147°58′25″E, sevt/*Brachychiton* in sandstone gully, dead among rocks and under logs, coll. C. Eddie, 22.vii.2004; QMMO65340, Carnarvon NP, Mt Moffatt Section, between Top and Rotary Shelter Sheds, 24°54031S, 148°02′11″E, open woodland, dead on ground, coll. C. Eddie, 6.x.1995; QMMO80655, 1A RC, Carnarvon NP, Mt Moffatt Section, Consuelo Tbld at head of Carnarvon Ck, 24°56′24″S, 148°04′14″E, open eucalypt woodland, dead on ground, coll. C. Eddie,15.xii.2002; QMMO80661, 1A RC, Carnarvon NP, Mt Moffatt Section, Consuelo Tbld, near Foley's Spring, 24°56′49″S, 148°07′55″E, tall eucalypt woodland/basalt tbld, dead on ground, coll. C. Eddie, R. Perry, 9-18.xii.2002; QMMO73104, 1A RC, Carnarvon NP, Mt Moffatt Section, Consuelo Tbld, near Bobindi Spring, 24°53′03″S, 148°12′11″E, grassy woodland, dead on ground, coll. C. Eddie, 17.xii.2002; QMMO73103, 1A SC/1A RC, Carnarvon NP, Mt Moffatt Section, Consuelo Tbld, c. 3.4 km E Racecourse Spring, 24°55′56″S, 148°05′51″E, open woodland, coll. C. Eddie, 14.ii.2002; QMMO73102, 1A SC/1A RC, Carnarvon NP, Mt Moffatt Section, Consuelo Tbld, near Foley's Spring, 24°56′49″S, 148°07′55″E, grassy woodland/ coll. C. Eddie, 13.ii.2002; AMSC143691, 1SA, Carnarvon Gorge area, 24°46′S, 147°46′E, open forest in basalt country, under log, coll. P.H. Colman, 1.x.1984; QMMO85280, 1SA RC, Carnarvon NP, Mt Moffatt Section, Meteor Ck below Kenniffs Cave, 24°52′02″S, 148°01′17″E, eucalypt woodland, dead on ground, coll. C. Eddie,21.i.1992; QMMO80662, 2A RC, Carnarvon NP, Carnarvon Gorge Section, at Nature Trail, 25°03′30″S, 148°14′17″E, open forest/*Casuarina*/*Livistona*, dead on ground, coll. C. Eddie, 25.xi.1995; QMMO80663, 1A RC, Carnarvon NP, Carnarvon Gorge Section, at Carnarvon Ck, 25°02′42″S, 148°11′00″E, *Livistona* understorey/ sandstone gorge, dead on ground, coll. C. Eddie, 25.xi.1995; QMMO73024, 1A SC/1A RC, Carnarvon NP, Carnarvon Gorge Section, along Nature Trail, 25°03′30″S, 148°14′07″E, woodland, dead on ground, coll. C. Eddie, 18.xii.1996; QMMO56635, 3A,1SA RC, Carnarvon NP, Carnarvon Gorge Section, beginning of gorge walk, 25°03′25″S, 148°13′30″E, *Livistona*/ *Cyathea*, under logs and rocks, coll. J. Stanisic, D. Potter, C. Eddie, 20.xi.1995; QMMO56650, 1A SC/12A,4SA RC, Moolayember Section, Carnarvon NP, Rolleston-Injune Rd, 25°13′55″S, 148°37′25″E, sevt/ ooline, under logs/dead on ground, coll. J. Stanisic, D. Potter, C. Eddie, 21.ix.1995; QMMO85450, 1A RC, Carnarvon Highway, Injune-Rolleston, in vicinity of Moolayember Ck, 25°10′44.2″S, 148°34′09″E, eucalypt woodland/open forest around sandstone rock outcrops, among leaf litter around rocks, coll. C. Eddie, 13.viii.2014.

Other material. Injune NW at Saddler's Springs Stn: QMMO80659, 1 SA RC. Carnarvon NP, Mt Moffatt Section, Rotary Shelter Shed: QMMO23529, 10SA SC/1A,3SA RC. Carnarvon NP, Mt Moffatt Section, Peawaddy Gorge: QMMO16565, 3A,8SA RC; QMMO65341, 1A SC; QMMO76308, 2SA SC. Carnarvon NP, Mt Moffatt Section, Mt Rugged: QMMO85277, 3SA RC. Carnarvon NP, Mt Moffatt Section, Consuelo Tbld: QMMO80654, 1SA SC.

Diagnosis. Shell large, subglobose, all-over yellowish brown to light brown with a slightly greenish tinge, occasionally with a reddish brown subsutural band; teleoconch with very fine, dense pustules and widely spaced oblique to zigzag microridgelets, body whorl with prominent curved growth lines. Apical walls of penial chamber with 6-7 occasionally anastomosing, fleshy longitudinal pilasters that become obliquely disposed medially and toward the atrium.

Description. Shell large, subglobose, all-over yellowish brown to light brown with a slightly greenish tinge, occasionally with a reddish brown subsutural band, spire weakly to

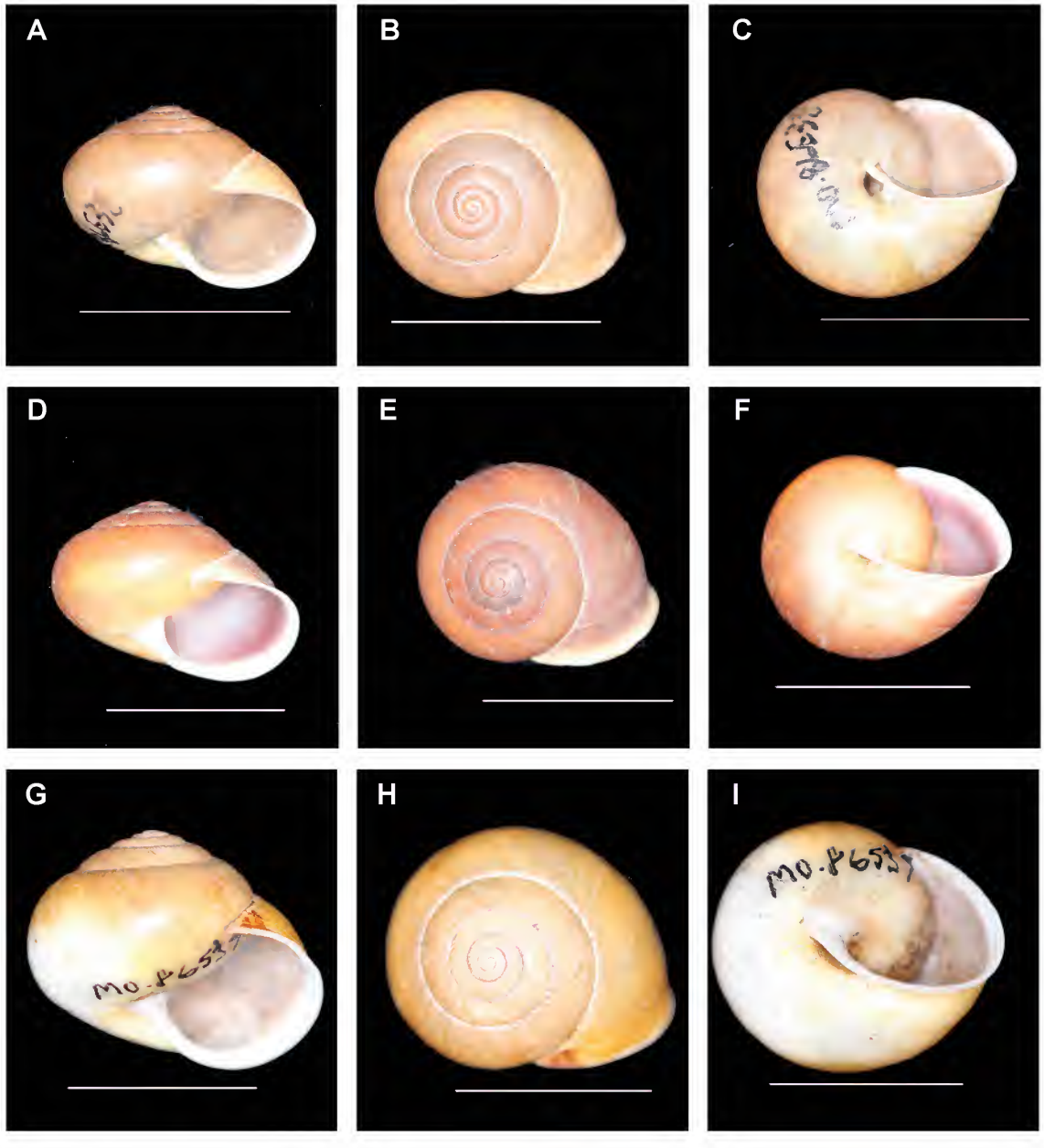

FIG. 11. *Pallidelix* holotypes. **A-C,** *P. staricki* sp. nov., QMMO86538; **D-F,** *P. lambkinae* sp. nov., QMMO86523; **G-I,** *P. moffatt* sp.nov., QMMO86537. Scale bars = 20 mm.

moderately elevated, whorls 5.125-6.0 (mean 5.500), evenly rounded the last descending in front (Fig. 11G-I). Height of shell 17.09-23.97 mm (mean 20.84 mm), diameter 23.15-28.58 mm (mean 25.97 mm), h/d 0.738-0.908 (mean 0.814). Protoconch as for genus. Teleoconch with very fine, crowded pustules and widely spaced oblique to zigzag microridgelets, sculpture persisting onto last half of body whorl, body whorl with prominent curved

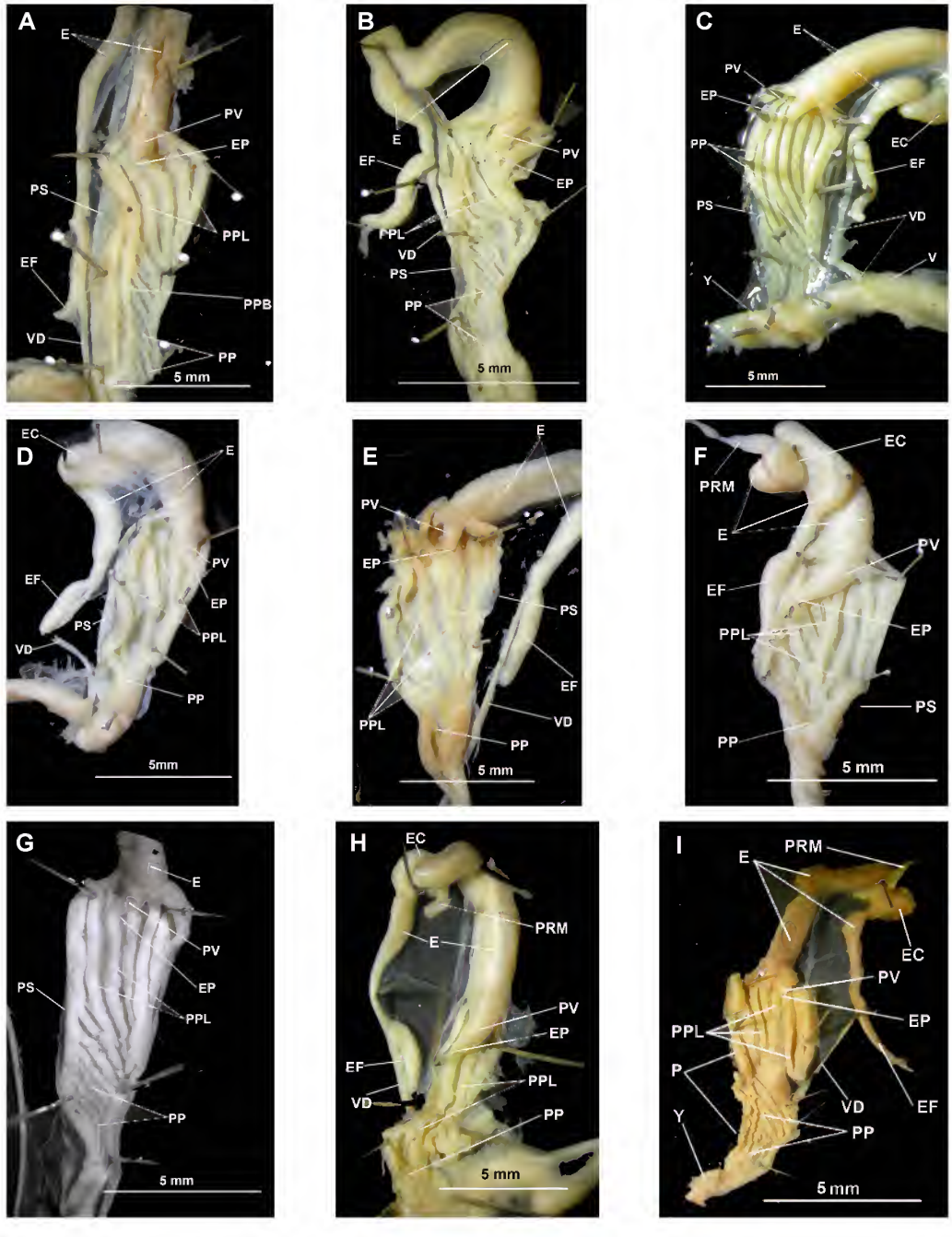

FIG. 12. Penial pilaster patterns in *Pallidelix*. **A**, *P. greenhilli* (Cox, 1866), QMMO79091; **B**, *P. lonesome* sp. nov., QMMO65168; **C**, *P. potteri* sp. nov., QMMO46301; **D**, *P. staricki* sp. nov., QMMO79085; **E**, *P. lambkinae* sp. nov., QMMO73020; **F**, *P. moffatt* sp. nov., QMMO85048; **G**, *P. simonhudsoni* Stanisic, 2015, QMMO80124; **H**, *P.minerva* sp. nov., QMMO56625; **I**, *P. zamia* sp. nov., QMMO68764.

growth lines (Fig. 7E); base shiny and smooth. Aperture roundly lunate, lip white, expanded and reflected; umbilicus reduced to a lateral crack. Based on 43 measured adults [QMMO85048 (22), QMMO80702 (8), QMMO80662 (2), QMMO85483 (5), QMMO73024 (1), QMMO80663 (1), QMMO56635 (4)].

Genitalia. Penis (P) long, tapered with slightly expanded apical bulb; thin sheath (PS) present; internally with a smooth papillate verge (PV), upper walls of penial chamber with 6-7 thick, fleshy, longitudinal pilasters (PPL) that occasionally anastomose and become obilquely disposed medially (PP) (Fig. 12F). Epiphallus (E) with relatively long, thick muscular curved ascending arm enveloped and partially folded within penial sheath, strongly reflexed and slightly twisted before giving rise to a thinner, relatively short arm; epiphallus entering penis through a simple pore (EP) situated terminally on verge. Penial retractor muscle (PRM) inserted at the fold of the two arms of the epiphallus adjacent to an epiphallic caecum (EC). Vas deferens (VD) thin, attached to penial sheath with connective tissue; a relatively long, thick finger-like epiphallic flagellum (EF) present at epiphallus-vas deferens junction, bound to vas deferens. Other structures as for genus and without unusual features. Based on four dissected specimens (QMMO73024, QMMO73095, QMMO73103, QMMO23542).

Distribution. Mt Moffatt , Carnarvon and Moolayember Sections, Carnarvon NP, SCQ.

Habitat. Eucalypt/palm and eucalypt woodland on sandstone; living under rocks and logs (Fig. 14A, B).

Remarks. *Pallidelix moffatt* sp. nov. is distinguished from the geographically adjacent *P. simonhudsoni* Stanisic, 2015 by a combination of shell with weakly to moderately elevated spire, teleoconch with scattered pustules and more widely spaced and more prominent microridgelets (Fig. 7E). *P. simonhudsoni* has a more elevated spire and more dense pustulation on the teleoconch with reduced microridgelets (Fig. 16A, B). Anatomically *P. moffatt* differs from *P. simonhudsoni* in having fewer penial pilasters that anastomose rather than simple and straight apical penial pilasters of the latter (cf. Fig. 12F, 12G)

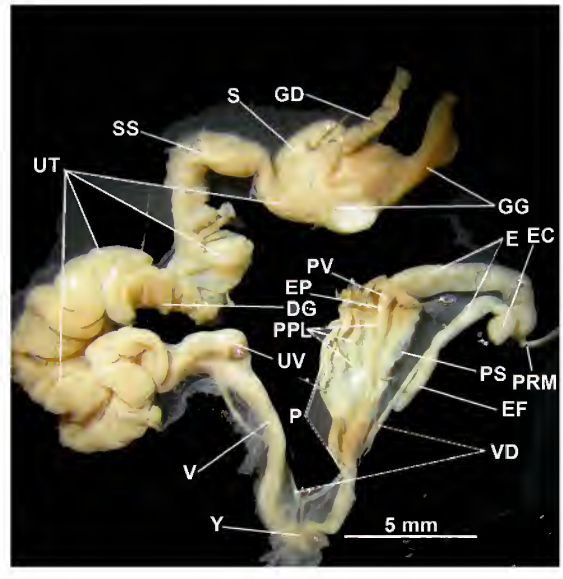

FIG. 13. Genitalia, *Pallidelix lambkinae* sp. nov., QMMO73020.

P. moffatt occurs over a large area of the topographically complex Carnarvon NP and as such is subject to the vagaries of local environmental conditions. Consequently specimens show a considerable size variation throughout the species' range. Average sized specimens occur in the central sandstone areas of the Mt Moffatt and Carnarvon Gorge Sections, however those from the more elevated, basalt capped, high rainfall Consuelo Tableland are considerably larger. Alternatively, those from the drier, more isolated dry vine thickets of the Moolayember Section are very much smaller. Ecologically *P. moffatt* differs from other *Pallidelix* species in showing a preference for woodland habitat on sandstone. Animal with reddish mantle.

Pallidelix simonhudsoni Stanisic, 2015 (Figs 12G, 16A-B)

Pallidelix simonhudsoni Stanisic, 2015: 56.

Preferred common name. Hudson's Woodland Snail.

Material examined. (All south central Queensland).

Holotype. QMMO80282, Fig Tree Spring, (24° 47.813'S, 147° 41.593'E), semi-evergreen vine thicket on basalt scree, under rocks, coll. J. Stanisic, 10.x.2014. Height of shell 28.02 mm, diameter 31.89 mm, h/d 0.879, whorls 5.875.

Other material examined. QMMO85328, 1A RC; QMMO56610, 2A SC/6A,17SA RC, Carnarvon NP, Ka Ka Mundi Section, SW Springsure, SCQ, 24°51'50"S, 147°26'35"E, eucalypt woodland with remnant vine thicket/sandstone, on ground, coll. J. Stanisic, D. Potter, C. Eddie,19.ix.1995; QMMO54833, 1SA RC, Carnarvon NP, Ka Ka Mundi Section, at Bottle Tree Flat, 24°48'27"S, 147°35'44"E, coll. W. McDonald, P. Grimshaw, 7.v.1993; QMMO54825, 2A RC, Carnarvon NP, Ka Ka Mundi Section, at Broad Gully Scrub, 24°47'54"S, 147°22'33"E, softwood scrub, coll. W. McDonald, R. Melzer, 6.v.1993; QMMO56616, 5A RC, Carnarvon NP, Ka Ka Mundi Section, 24°45'30"S, 147°20'37"E, sevt/basalt scree, in litter, coll. J. Stanisic, D. Potter, C. Eddie, 19.ix.1995; QMMO66031, 1A,1SA RC, Carnarvon NP, Ka Ka Mundi Section, 24°49'55"S, 147°33'40"E, coll. T. Vincent, 19.vi.1999; QMMO56200, 3A,1SA RC, Carnarvon NP, Ka Ka Mundi Section, around cattle yards below Fig Tree Spring, 24°48'35"S, 147°35'35"E, low brigalow woodland, on ground, coll. C. Eddie, 2.ii.1995; QMMO56612, 9A,2SA RC, Carnarvon NP, Ka Ka Mundi Section, 24°49'40"S, 147°24'47"E, sevt/ *Brachychiton*, under and in logs, coll. J. Stanisic, D. Potter, C. Eddie, 19.ix.1995.

Other material. All from Carnarvon Station Reserve as listed in Stanisic (2015).

Diagnosis. Shell large with a moderately to strongly elevated spire and rounded whorls, dark to yellowish brown, occasionally with a thin reddish brown subsutural band; teleoconch sculpture of relatively fine, crowded pustules and scattered oblique to zigzag microridgelets. Penis internally with 4-5 straight, smooth, thick longitudinal pilasters apically becoming obliquely disposed medially and thinner, straight and corrugated toward the atrium. Epiphallic flagellum and caecum present. Modified from Stanisic (2015).

Distribution. Carnarvon Station Reserve and part of Ka Ka Mundi Section, Carnarvon NP, SCQ.

Habitat. Vine thicket on basalt and sandstone; living under rocks and logs (Stanisic 2015).

Remarks.Conchologically *Pallidelix simonhudsoni* Stanisic, 2015 is distinguished from *P. moffatt* sp. nov. by a combination of strongly elevated spire and predominantly fine pustules on the teleoconch (Fig. 12 A, B). Anatomically the simple apical penial pilasters of *P. simonhudsoni* contrast with the more numerous anastomosing pilasters of *P. moffatt* sp. nov (cf. Fig. 12F & Fig. 12G). Previously recorded from Carnarvon Station the range of the species is extended to include the immediately adjacent parts of Ka Ka Mundi Section, Carnarvon NP, SCQ. Animal with reddish mantle.

The modified diagnosis now includes the presence of an epiphallic caecum which was previously mistaken for a simple distension of the epiphallus (Stanisic 2015).

Pallidelix grandis sp. nov.
(Figs 15A-C, 17A)

Etymology. From the Latin *grandis* = large, referring to the large size.

Preferred common name. Giant Woodland Snail.

Material examined. (All mid-central Queensland).

Holotype. QMMO85327, Springsure, W at upper Vandyke Ck, 24°38'45"S, 147°51'13"E, vine thicket/ softwood scrub, on ground, coll. W. McDonald, P. Grimshaw, 9.v.1993. Height of shell 35.81 mm, diameter 35.48mm, h/d 1.009, whorls 6.125.

Paratypes. QMMO54832, 11A RC, same data as holotype; QMMO79359, 4A RC, Carnarvon NP, Ka Ka Mundi section, at Dry Creek, 24°41'55"S, 147°39'53"E, sevt on creek terrace, under rocks, coll. C. Eddie, W. Mc Donald, 10.viii.2004; QMMO85459, 17A,6SA RC, Springsure, 74 km SW at Tanderra Stn, 24°37'51"S, 147°43'04"E, sevt, dead on ground/ among leaf litter under/inside logs, coll. C. Eddie, W. McDonald, 12.viii.2004; QMMO79355, 10A RC, Carnarvon NP, via Tanderra Stn, 24°42'27"S, 147°45'48"E, sevt on basalt beside creek, coll. C. Eddie, W. McDonald,11.viii.2004; QMMO85460, 1A RC, Springsure, 74 km SW at Tanderra Stn, 24°42'06"S, 147°44'22"E, sevt on basalt ridge, dead on ground/among leaf litter under rocks and logs, coll. C. Eddie, W. McDonald, 11.viii.2004.

Other material examined. QMMO55443, 4A RC, Carnarvon NP, 24°35'30"S, 147°43'05"E, on ground, coll. C. Eddie, 2.ii.1995; QMMO85461, 5A/5SA RC, Carnarvon NP, Ka Ka Mundi section, above Dry Creek, 24°41'40"S, 147°40'53"E, sevt/gully on basalt ridge, dead on ground/among leaf litter under logs and rocks, coll. C. Eddie, W. Mc Donald, 10.viii.2004; QMMO85457, 1A RC, Carnarvon NP, via Tanderra Stn, 24°42'22"S, 147°45'52"E, sevt on creek terrace/basalt, dead on ground, coll. C. Eddie, W. McDonald,11.viii.2004.

Diagnosis. Shell very large, globose with an elevated spire and expanded body whorl; teleoconch sculpture of very weak, low and fine, oblique to zigzag microridgelets and scattered fine pustules on early whorls, reduced to obsolete on last half of body whorl; umbilicus closed by reflexion of the columella. Anatomy unknown.

Description. Shell very large, globose with an elevated spire and expanded body whorl, yellowish brown to brown, shiny; whorls 5.750-6.500 (mean 6.125), evenly rounded above and slightly shouldered below the periphery, the last descending rapidly in front (Fig. 15A-C). Height of shell 29.09-36.40 mm (mean 32.22 mm), diameter 30.51-36.65 mm (mean 33.33 mm), h/d 0.851-0.1.060 (mean 0.903). Protoconch as for genus. Teleoconch sculpture of very weak, low and fine, oblique to zigzag microridgelets and scattered pustules on early whorls, reduced to obsolete on last half of body whorl (Fig. 17A); base shiny and smooth. Aperture roundly lunate, lip white, expanded and reflected; umbilicus closed by reflexion of columella. Based on 30 measured adults [QMMO79355 (10), QMMO79359 (4), QMMO55443 (4), QMMO54832 (12)].

Anatomy unknown.

Distribution. Northern Ka Ka Mundi and Welcome Sections, Carnarvon NP, north to Tanderra Stn, south of Springsure and environs, MCQ.

Habitat. Vine thicket on basalt; living under rocks and logs (Fig. 14C-D).

Remarks. *Pallidelix grandis* sp. nov. is readily distinguished from congeners by the very large shell with expanded body whorl having weak to obsolete sculpture and a closed umbilicus (FIGS 15C, 17A). The somewhat similar *P. lonesome* sp. nov. from the Arcadia Valley has a smaller shell with very weak sculpture persisting on the last part of the body whorl and a slightly open umbilicus (Figs 4, 6C). Although the existing specimens of *P. grandis* chiefly come from the vicinity of Tanderra Station, the locality of the holotype (upper Van Dyke Creek) suggests that the species may be may be more widely spread along that extensive drainage system.

Pallidelix minerva sp. nov.
(Figs 7E, 12H, 15D-F, 19D)

Etymology. For the Minerva Hills, Springsure.

Preferred common name. Minerva Hills Woodland Snail.

Material examined. (All mid-central Queensland).

Holotype. QMMO85325, Springsure, NW at Mt Zamia, Minerva Hills, 24°05′55″S, 148°05′00″E, sevt, under rocks and logs, coll. J. Stanisic, D. Potter, C. Eddie, 20.ix.1995. Height of shell 23.42 mm, diameter 29.97mm, h/d 0.781, whorls 5.625.

Paratypes. QMMO56625, 1A,1SA SC/5A,10SA RC, same data as holotype; QMMO35822, 4A RC, Virgin Rock, 2 km N Springsure, 24°05′50″S, 148°05′15″E, under rock in vine thicket, coll. V. Kessner, 5.iii.1992; QMMO73307, 3A,3SA RC, Minerva Hills NP, NNW Springsure, 24°05′47″S, 148°04′52″E, sevt, under rocks at base of fig, coll. C. Eddie, 21.iii.2001.

Other material examined. QMMO54813, 3A,1SA RC, Springsure, N at Mt Hope, 24°06′07″S, 148°06′56″E, sevt, coll. W. Mc Donald, P. Grimshaw, 14.v.1993; QMMO44089, 1SA RC, adjacent to Mt Wills, on Mt Helmet-Springsure Rd, 24°59.5′S, 147°55.5′E, vine thicket on basalt, under rocks, coll. J. Stanisic, D. Potter, 20.vi.1992; QMMO68762, 1A RC, Springsure, NW, 0.6 km SSW of Mt Zamia. 24°06′S, 148°05′E, alt. 360 m, vine thicket, coll. D. Cook, 17.xii.2000.

Diagnosis. Shell large, depressedly globose, yellowish brown to brown with thin reddish brown subsutural band and lighter coloured base; teleoconch sculpture of densely crowded pustules on the early whorls and oblique to zigzag microridgelets and pustules on the body whorl. Upper walls of penial chamber with 3-4 fleshy longitudinal pilasters, irregular corrugated pilasters basally.

Description. Shell large, depressedly globose, yellowish brown to brown with thin reddish brown subsutural band and lighter coloured base; spire weakly elevated; whorls 5.375-5.825 (mean 5.625), evenly rounded, the last descending in front (Fig. 15D-F). Height of shell 19.17-23.87 mm (mean 20.68 mm), diameter of shell 25.96-28.64 mm (mean 27.55 mm), h/d 0.700-0.844 (mean 0.751). Protoconch as for genus. Teleoconch sculpture of densely crowded pustules on the early whorls and oblique to zigzag microridgelets and pustules on the body whorl (Fig. 7E); base shiny and smooth. Aperture roundly lunate, lip white, expanded and reflected; umbilicus

FIG. 14. *Pallidelix* habitats. **A-B**, *P. moffatt* sp. nov.: **A**, Marlong Plain, Mt Moffatt, SCQ; **B**, Carnarvon Gorge, SCQ. **C-D**, *P. grandis* sp. nov.: Tanderra Stn, MCQ; **E**, *P. minerva* sp. nov.: Minerva Hills, MCQ; **F**, *P. zamia* sp. nov.: Drummond Range, MCQ. Images: A-D & F, C. Eddie.

reduced to a lateral crack. Based on 16 measured adults [QMMO68762 (1), QMMO73307 (3), QMMO35822 (4), QMMO54813 (2), QMMO56625 (6)].

Genitalia. Penis (P) long, tapered with slightly expanded apical bulb; thin sheath (PS) present; internally with a smooth papillate verge (PV), upper walls of penial chamber with 3-4 fleshy longitudinal pilasters (PPL) and irregular corrugated pilasters basally (PP) (Fig. 12I). Epiphallus (E) with relatively long, thick muscular, curved ascending arm enveloped and partially folded within penial sheath, strongly reflexed and slightly twisted before giving rise to a thinner, relatively short arm; epiphallus entering penis through a simple pore (EP) situated terminally on verge. Penial retractor muscle (PRM) inserted at the fold of the two arms of the epiphallus adjacent to an epiphallic caecum (EC). Vas deferens (VD) thin, attached to penial sheath with connective tissue; a relatively short, thick, finger-like epiphallic flagellum (EF) present at epiphallus-vas deferens junction, bound to vas deferens. Other structures as for genus and without unusual features. Based on one dissected specimen (QMMO78764).

Distribution. Minerva Hills, via Springsure, MCQ.

Habitat. Vine thicket and adjacent ironbark woodland; living under logs and rocks (Fig. 14E).

Remarks. *Pallidelix minerva* sp. nov. is distinguished by a combination of shell with prominent pustulation on the teleoconch whorls (Fig. 7E) and penis with 3-4 apical longitudinal pilasters (Fig. 12H). *P. zamia* sp. nov. from the Drummond Range has less pustulose shell sculpture and a greater number of apical longitudinal penial pilasters (FIGS 12I, 17B). Animal with beige-coloured mantle.

Pallidelix zamia sp. nov.
(Figs 12I, 15G-I)

Etymology. For Mt Zamia, Drummond Range.

Preferred common name. Drummond Range Woodland Snail

Material examined. (All mid-central Queensland).

Holotype. QMMO68563, Emerald, W at Drummond Ra.,13km N Bogantungan, 23°32'08"S, 147°19'21"E, alt. 680 m, rocky gully, near fig trees, coll. D. Cook, 8.x.2000. Height of shell 25.45 mm, diameter 29.52 mm, h/d 0.862, whorls 5.625.

Paratype. QMMO68764, 1A,1SA SC/1A RC, summit of Drummond Ra., W of Emerald, 23°32'S, 147°18'E, coll. D. Cook, 25.x.2000.

Other material examined. QMMO76389, 1SA RC, Emerald, W, c. 13.5k N of Bogantungan, 23°32'S, 147°18'E, alt. 880m, open forest, coll. D. Cook, G. Monteith, 27.iii.2001; QMMO76685, 4SA RC, Emerald, W at Mt Drummond Ra., summit, 23°32'S, 147°18'E, alt. 920 m, open forest, coll. QM party, 26.x.2000.

Diagnosis. Shell large, subglobose, yellowish brown to brown with a weak reddish brown subsutural band; teleoconch sculpture of fine, crowded pustules and weak oblique microridgelets on the early whorls and crowded, prominent, oblique to zigzag microridgelets and reduced pustules on the latter whorls. Upper penial chamber with 7-8 thick, fleshy longitudinal pilasters becoming thin and corrugated basally.

Description. Shell large, subglobose, yellowish brown to brown with a weak reddish brown subsutural band; spire weakly elevated; whorls 5.625-5.750 (mean 5.625), evenly rounded, the last descending in front (Fig. 15D-F). Height of shell 24.36-25.45 mm (mean 24.90 mm), diameter of shell 28.59-29.52 mm (mean 29.05 mm), h/d 0.852-0.862 (mean 0.857). Protoconch as for genus. Teleoconch sculpture of fine, crowded pustules and weak oblique ridges on the early whorls and fine crowded, prominent, oblique to zigzag microridgelets and reduced pustules on the latter whorls (Fig. 17B); base shiny and smooth. Aperture roundly lunate, lip white, expanded and reflected; umbilicus reduced to a chink. Based on 2 measured adults [QMMO68563 (1), QMMO68764 (1)].

Genitalia. Penis (P) long, tapered with slightly expanded apical bulb; thin sheath (PS) present; internally with a smooth papillate verge (PV), upper walls of penial chamber with 7-8 fleshy longitudinal pilasters (PPL), becoming thin and corrugated basally (PP) (Fig. 12I). Epiphallus (E) with relatively long, thick muscular curved ascending arm enveloped and partially folded within penial sheath, strongly reflexed and slightly twisted before giving rise to a thinner,

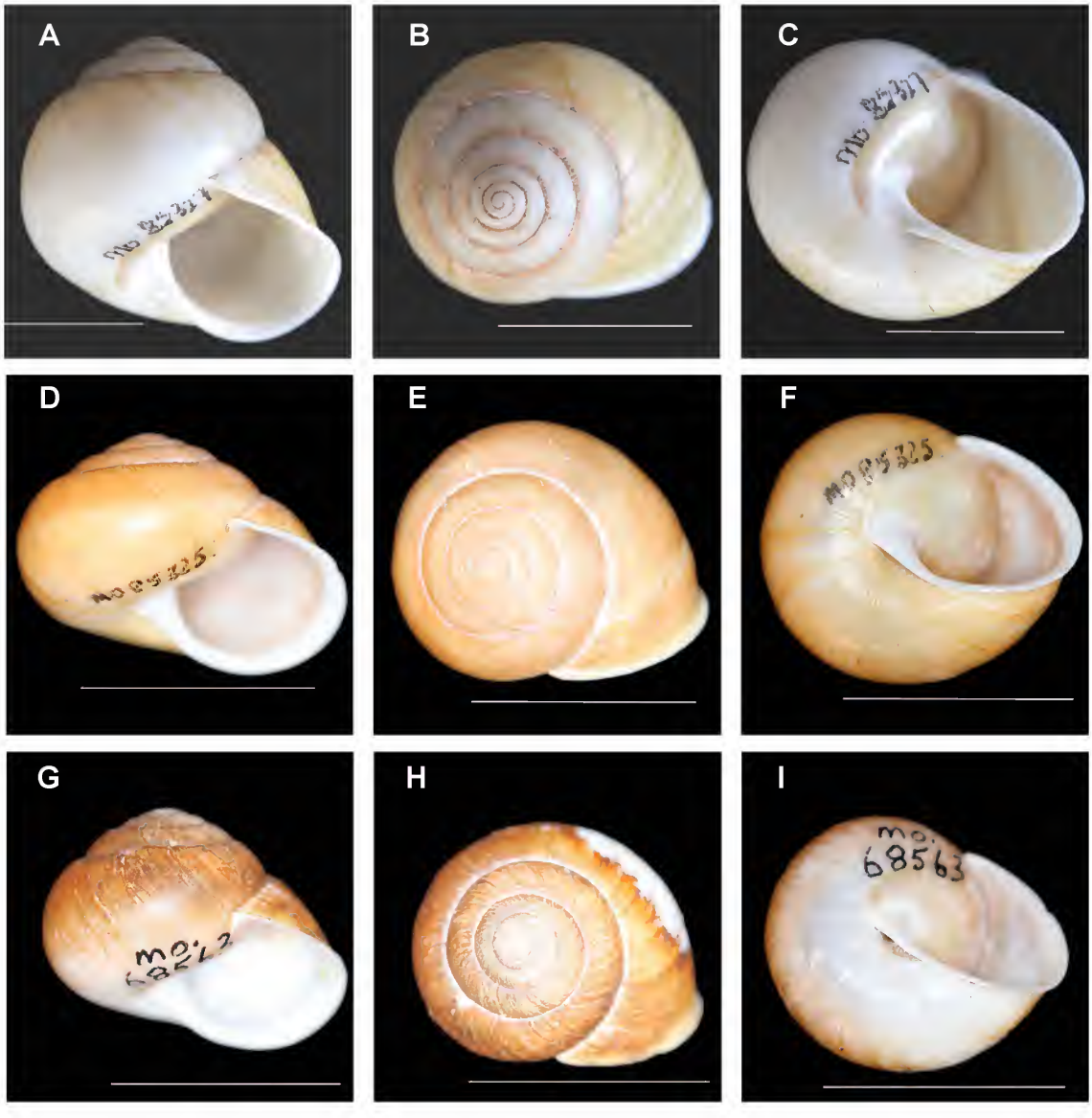

FIG.15. *Pallidelix* holotypes. **A-C**, *P. grandis* sp. nov., QMMO85327; **D-F**, *P. minerva* sp. nov., QMMO85325; **G-I**, *P. zamia* sp. nov., QMMO68563. Scale bars = 20 mm.

relatively short arm; epiphallus entering penis through a simple pore (EP) situated terminally on verge. Penial retractor muscle inserted at the fold of the two arms of the epiphallus adjacent to an epiphallic caecum (EC). Vas deferens (VD) thin, attached to penial sheath with connective tissue; a long, thick, finger-like epiphallic flagellum (EF) present at epiphallus-vas deferens junction, bound to vas deferens. Other structures as for genus and without unusual features. Based on one dissected specimen (QMMO78764).

Distribution. Drummond Range, W of Emerald, MCQ.

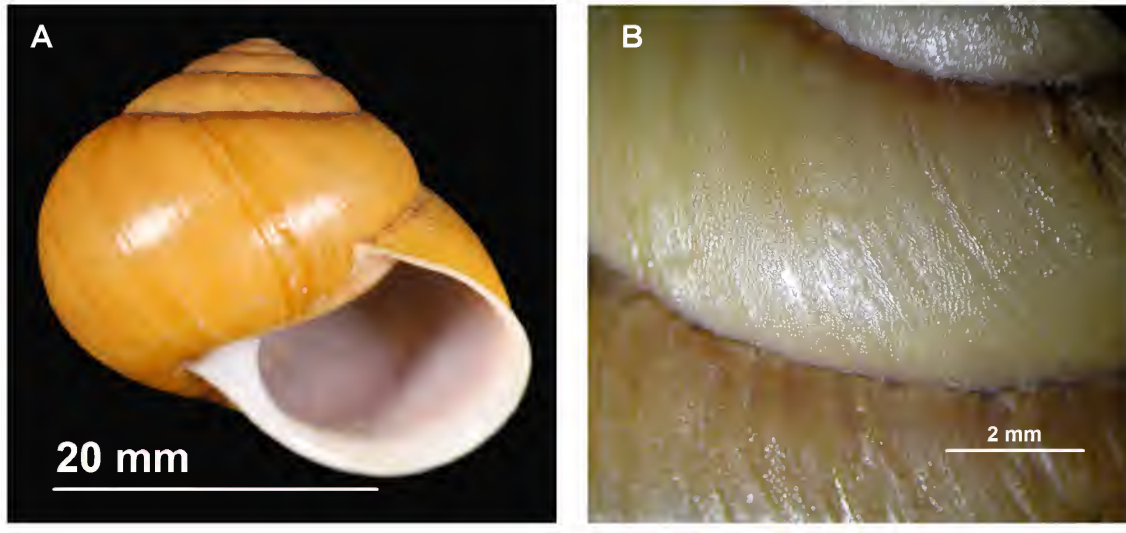

FIG. 16. Holotype of *Pallidelix simonhudsoni* Stanisic, 2015, QMMO 80282, Carnarvon Stn Reserve, SCQ. **A**, Shell; **B**, Teleoconch sculpture.

Habitat. Remnant thicket and adjacent open forest; among rocks and logs (Fig. 14F).

Remarks. *Pallidelix zamia* sp. nov. differs from *P. minerva* sp. nov. by the shell sculpture of prominent oblique to zigzag microridgelets and reduced pustulation on the latter teleoconch whorls (Fig. 17B) in contrast to the prominent pustulation and reduced microridgelets on the latter part of the teleoconch of the latter (Fig. 7E). Anatomically *P. zamia* differs from *P. minerva* by having more numerous apical longitudinal penial pilasters (cf. Fig. 12H, 12I).

Collecting to the north of the Drummond Range has not produced any additional specimens of *Pallidelix* indicating that *P. zamia* is the most northerly species of the genus.

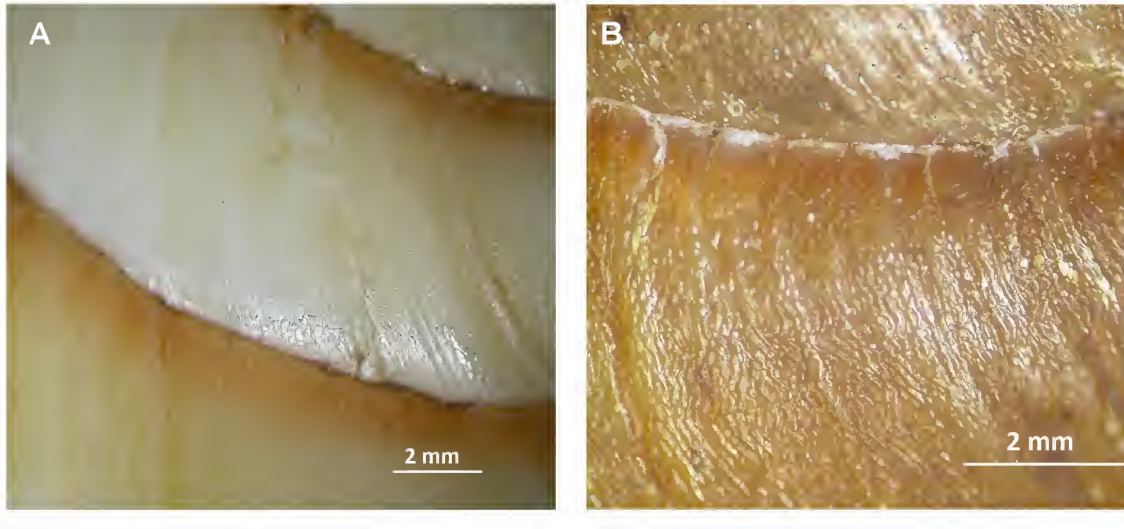

FIG. 17. Teleoconch sculpture. **A**, *Pallidelix grandis* sp. nov., QMMO85327; **B**, *Pallidelix zamia* sp. nov., QMMO68563.

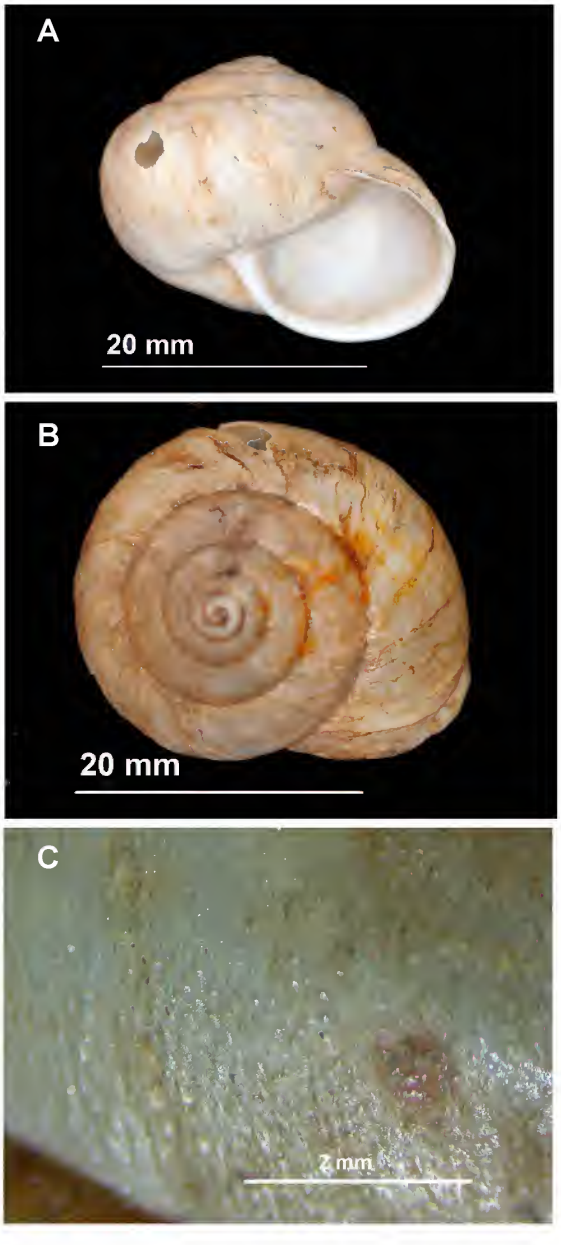

FIG. 18. *Helix expeditionis* Cox, 1868. Lectotype, AMSC33232. **A**, apertural view; **B**, dorsal view; **C**, shell sculpture showing pustules and no microridgelets.

Incertae sedis
Helix expeditionis Cox, 1868
(Fig. 18A-C)

Helix expeditionis Cox, 1868: 37; Stanisic *et al.*, 2010: 541 (in synonymy).
Meridolum expeditionis (Cox). Iredale, 1938: 84.
Galadistes expeditionis (Cox). Smith, 1992: 126.

Lectotype (herein designated (Fig. 18A, B). AMSC33232, Tropical Australia. Pres. Sir Thomas Mitchell. Height of shell 21.70 mm, diameter 27.17 mm, h/d whorls 0.797, whorls 5.375.

Paralectotype. AMSC559601, 1 damaged SA RC, same data as lectotype.

Remarks. Stanisic *et al.* (2010) placed *Helix expeditionis* Cox, 1868 in the synonymy of *Pallidelix greenhilli sensu lato* based on the vague type locality and Iredale's (1938) annotation ' north of the preceding' referring to a species from the Darling Downs, SEQ. However, a more detailed examination of the shell sculpture and comparison with the large amount of shell material made available for this revision, has led to a reappraisal of its status.

The syntype specimens of *Helix expeditionis* were putatively presented to the Australian Museum, Sydney by explorer Sir Thomas Mitchell. The type locality on the labels associated with the specimens is given as 'Tropical Australia' presumably alluding to his fourth expedition into inland Queensland. The expedition recorded as the 'Expedition into Tropical Australia', encompassed the Central Highlands of central inland Queensland but largely west of the *Pallidelix* distribution. This expedition was recorded in one of his many journals together with a list of specimens (animals and plants) collected on the trip (Mitchell, 1848). No snails were listed in the species inventory or mentioned in the expedition narrative. It may be possible that the specimens came from one of Mitchell's other expeditions or bear no relevance to these at all.

The lectotype of *H. expeditionis* Cox, 1868 is a grey coloured, worn and damaged shell (Fig.18A, B). The teleoconch features curved growth lines and a sculpture of very fine but worn, crowded pustules which become less noticeable on the last half of the body whorl. The sub-adult paralectotype (5.125 whorls) has similar but more defined pustulation on the teleoconch. Although there

are traces of periostracum on both shells there are no microridgelets present. The protoconchs of the two specimens exhibit sparse pustules and irregular rugose ridges (Fig. 18C). This is not the pattern seen in *Pallidelix* spp. The lack of any microridgelets on the teleoconch indicates that these specimens do not belong to *Pallidelix*.

The two shells in question most closely resemble some camaenids (many undescribed) from the southern Brigalow Lands bioregion in the vicinity of Dalby and Miles, SEQ. However, at present it is not possible to definitively associate the specimens of *H. expeditionis* with any extant species from that area. Hence, *Helix expeditionis* must be considered *incertae sedis* for the foreseeable future or at least until a full revision of the southern brigalow camaenids is completed and when a reassessment can be undertaken.

DISCUSSION

Pallidelix is one of the most dominant and widespread camaenid genera in the central highlands of inland Queensland (Stanisic, pers. obs.). Main areas of distribution are the Expedition and Carnarvon ranges with several outlier species occurring both to the north and south. The *Pallidelix* distribution chiefly comprises the Queensland Sandstone Belt which covers an area of approximately 82,000 square kilometres in south central Queensland. Consisting mainly of sandstone cliffs and deeply incised gorges the region's west also features basalt crested mountains and plateaux. The area occupied by the genus encompasses the various sections of the largely sandstone Carnarvon NP (*P. moffatt* sp. nov., *P. simonhudsoni* Stanisic, 1915 and *P. grandis* sp. nov.) and Expedition Range NP (*P. greenhilli* (Cox, 1866), *P. expeditiana* sp. nov.). One species occurs in the Arcadia Valley (*P. lonesome* sp. nov.). In addition the range of the genus also extends to the sandstone plateau of the Blackdown Tableland to the north of the Expedition Range at the junction of the Shotover and Dawson Ranges (*P. potteri* sp. nov.) and the volcanics of the Minerva Hills (*P. minerva* sp. nov.) and Drummond Range (*P. zamia* sp. nov.) in the north-west central highlands. To the south of the Expedition Range species also occur in the Nuggett Hill/ Pony Hills area east of Injune (*P. staricki* sp. nov.) and in the Gurulmundi SF, north of Miles (*P. lambkinae* sp. nov.) (Fig. 20).

The majority of species appear to have relied on scattered vine thickets for their existence in a landscape dominated by brigalow/woodland, and in many cases, lithorefugia (sandstone and basalt outcrops) have provided the microhabitats for their survival. While most species of *Pallidelix* now inhabit scattered patches of vine thicket and moist palm forest, one occurs primarily in the drier woodland communities of the Carnarvon NP (*P. moffatt*).

Size of species distributions range from the widespread (*P. moffatt*, *P. expeditiana*) to the very circumscribed and narrow (*P. greenhilli*). Most species occur in vine thicket patches isolated by the scattered nature of lithologies on which they occur. These patches are both climatically and topographically isolated in a semi-arid landscape and in many cases the isolation has been long term presumably dating from the climatic induced contractions of mesic communities in the Plio-Pleistocene.

A sizeable part of the area occupied by *Pallidelix* species is now mainly used for farming and agriculture and is largely devoid of natural vegetation, as is the case with a major proportion of the Brigalow Lands bioregion (Fensham 1996). Fortunately, a large percentage of the remaining but often fragmented natural vegetation within the *Pallidelix* distribution range (including the vitally important vine thickets) is secured in national parks and conservation reserves. However, a small but nonetheless significant number of vine thickets exist outside these conservation jurisdictions and these are open to exploitation. In more recent times mining development (coal and gas) has contributed to additional habitat fragmentation through the construction of service roads, open cut pits and gas well pads. The large scale habitat loss (historical and recent) has made collecting live snails very difficult and has contributed greatly to the somewhat constrained nature of this revision. *Pallidelix* highlights the importance of the vine thicket archipelago embedded within

FIG. 19. **A**, *Pallidelix lonesome* sp. nov., QMMO65168, Lonesome NP, SCQ; **B**, *P. expeditiana* sp. nov., QMMO56544, NW of Taroom, SCQ; **C**, *P. potteri* sp. nov., QMMO44111, Charlevue Ck, SCQ; **D**, *P. minerva* sp. nov., QMMO56625, Mt Zamia, Minerva Hills, SCQ; **E**, *P. expeditiana* sp. nov. , Wallaroo Stn, SCQ; **F**, *P. lambkinae* sp. nov., QMMO86523, Stones Country Resource Reserve, SCQ; **G**, *P. staricki* sp. nov., QMMO86518, Strathblane Stn, SCQ. **H**, *P. expeditiana* sp. nov., QMMO85296, Fairview Holding, SCQ; Images: E-H, Craig Eddie.

the brigalow woodland communities. These vine thickets are vitally important not only for *Pallidelix* spp. and many other land snails but also for a range of other invertebrates. Their destruction has undoubtedly led to species' extinctions in the past and will continue to do so in the future unless the remaining patches (no matter how small) outside of conservation jurisdictions are provided with some formal protection.

This revision of *Pallidelix* should not be regarded as definitive. The study is based on many but mostly small, conchological datasets chiefly collected as dead shells and hence of variable quality for the study of sculptural features. Similarly animal datasets were scarce and in several cases the detail of reproductive anatomy is based on one or two specimens. The absence of sufficient and competent (fresh) material for molecular studies is considered a drawback that can and needs to be addressed in the future through additional field work if these proposed species are to be confirmed. This process will be difficult in what is now a fragmented landscape. The magnitude of this task is poignantly highlighted by the recent donation of 548 specimens of camaenids from the central highlands of which only seven represented live snails in spite of intensive searching by an expert field malacologist. However, this revision provides a roadmap for the collection of suitable animal material for genetic studies in the future by identifying species-level trends in the genus and the location of habitats in which these occur.

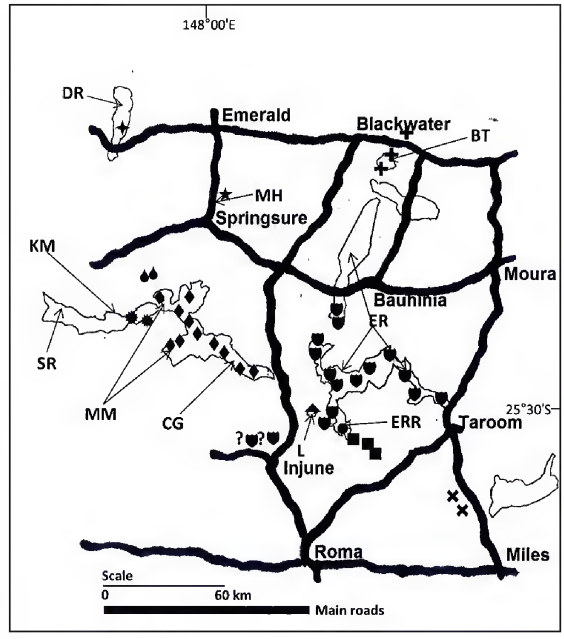

FIG. 20. Diagrammatic representation of *Pallidelix* distribution. ●, *P. greenhilli* (Cox, 1866); ▲, *P. lonesome* sp. nov.; ⛊, *P. expeditiana* sp. nov. (?⛊ = Crowman, Oakwells populations); ✚, *P. potteri* sp. nov.; ■, *P. staricki* sp. nov.; ✖, *P. lambkinae* sp. nov.; ♦, *P. moffatt* sp. nov.; ✹, *P. simonhudsoni* Stanisic, 2015; ♠, *P. grandis* sp. nov.; ★, *P. minerva* sp. nov.; ✦, *P. zamia* sp. nov. [Locations: BT, Blackdown Tableland NP; CG, Carnarvon Gorge Section; DR, Drummond Range; ER, Expedition Range NP; ERR, Expedition Resource Reserve; KM, Ka Ka Mundi Section; L, Lonesome NP; MH, Minerva Hills; MM, Mount Moffatt Section; SR, Salvator Rosa Section].

KEY TO THE GENUS *PALLIDELIX*

(Sculptural detail refers to the last three whorls of the teleoconch only)

1. Umbilicus closed, shell very large with greatly expanded body whorl, reduced sculpture to smooth on body whorl; Tanderra Stn, south of Springsure and environs ..... *Pallidelix grandis* sp. nov.
– Umbilicus a lateral crack, sculpture variable. 2
2. Body whorl greatly expanded, shell large, reduced sculpture on body whorl; Lonesome Section and environs, Expedition Range NP ..... *Pallidelix lonesome* sp. nov.
– Body whorl evenly expanded, shell medium-sized to large 3
3. Spire moderately to strongly elevated, with prominent pustulation and reduced microridgelets; Carnarvon Station Reserve and Ka Ka Mundi Section, Carnarvon NP ..... *Pallidelix simonhudsoni* Stanisic, 2015
– Spire weakly to moderately elevated 4
4. Spire weakly elevated, with prominent, crowded microridgelets and reduced pustulation; ESE of Injune to NE Miles .. 5
– Spire moderately elevated 6
5. Prominent crowded microridgelets; ESE Injune: Spring Gully Stn, Nuggett Hills Stn, Pony Hills..... *Pallidelix staricki* sp. nov.
– Prominent crowded microridgelets;

NE Miles: Gurulmundi SF ..... *Pallidelix lambkinae* sp. nov.

6. Body whorl large, shell shiny with moderately spaced, prominent zigzag microridgelets and reduced pustulation; Expedition Resource Reserve and environs ..... *Pallidelix greenhilli* (Cox, 1866)

– Body whorl medium-sized with crowded microridgelets and variable pustulation .. 7

7. Pustulation and microridgelets equally prominent..... 8

– Pustulation and microridgelets variable intensity 9

8. Weak microridgelets and coarse pustulation; Expedition Range NP ..... *Pallidelix expeditiana* sp. nov.

– Pustulation and microridgelets equally prominent; Carnarvon NP ..... *Pallidelix moffatt* sp. nov.

9. Very prominent pustulation and reduced microridgelets; Minerva Hills ..... *Pallidelix minerva* sp. nov.

– Reduced pustulation and very prominent microridgelets 10

10. Crowded oblique to zigzag microridgelets and scattered pustules; Blackdown Tableland NP and environs ..... *Pallidelix potteri* sp. nov.

– Crowded microridgelets and obsolete pustulation; Drummond Range ..... *Pallidelix zamia* sp. nov.

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This study could not have been successfully undertaken without the help of Roma-based environmental consultant and malacologist, Craig Eddie. His collecting efforts in the Roma-Injune-Carnarvon Range-Expedition Range area have contributed greatly to a more comprehensive understanding of the diversity and distribution of camaenids in the Queensland Central Highlands. I am extremely grateful to him for donating his material for study and for providing images of habitats and live snails. Thanks are also due to Darryl Potter (Collection Manager, Queensland Museum) and Lorelle Holcroft (Volunteer, Queensland Museum) for assistance with curation and databasing of specimens; to Alison Miller (Australian Museum) for expediting the loan of type material.

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A Queensland Government Project
Typeset at the Queensland Museum

A new genus to accommodate three skinks currently assigned to *Proablepharus* (Lacertilia: Scincidae)

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ABSTRACT

The genus *Proablepharus* currently contains five species (*P. barrylyoni, P. kinghorni, P. naranjicaudus, P. reginae* and *P. tenuis*). Morphologically, these are readily separated into two groups: the small, almost patternless species (*P. reginae* and *P. tenuis)* and the larger, striped species (*P. kinghorni, P. barrylyoni* and *P. naranjicaudus*). We present genetic and morphological data to demonstrate that these two groups are generically distinct from each other. As *P. reginae* is the type species for *Proablepharus*, we erect a new genus, *Austroablepharus* gen. nov., for the *kinghorni* group and designate *A. kinghorni* as the type species. ❐ *Proablepharus, Austroablepharus gen. nov., Australia, morphology, genetics.*

The genus *Proablepharus* was erected by Fuhn (1969) in a revision of skinks assigned to *Ablepharus* Fitzinger 1823. Fuhn (1969) separated *A. reginae* Glauert 1960 and *A. tenuis* Broom 1896 into *Proablepharus* which he defined by the following traits: 'pentadactyle; no supranasals; frontoparietals paired; interparietal present'. Fuhn failed to designate a type species for the genus. Greer (1974) considered *Proablepharus* as containing three species: *P. reginae*, *P. davisi* (Copland 1952) and *P. kinghorni* (Copland 1947), and designated *Proablepharus reginae* as the type-species. He left *Ablepharus tenuis* and *Ablepharus broomensis* Lönnberg & Andersson 1913 as species *incertae sedis* (i.e., unassigned) pending the opportunity to examine a palatal feature of their skulls. Greer (1974) diagnosed *Proablepharus* as: 'Small (snout-vent length 45 mm or less), terrestrial skinks which lack supranasals, possess an ablepharine eye and have the interparietal distinct from the frontoparietal(s). Frontoparietals distinct (*reginae*) or fused (*kinghorni* and *davisi*); frontal in contact with 2 of 4 supraoculars (*reginae* and *kinghorni*) or 1 of 3 supraoculars (*davisi*).' Storr (1975), in discussing the two Western Australian species, recognised *P. reginae* and *P. tenuis*, and placed *broomensis* and *davisi* in the synonymy of *P. tenuis*. This left *Proablepharus*

FIG. 1. *Proablepharus reginae* showing a drab brown, relatively uniform pattern; Tennant Creek, Northern Territory (Image: Steve Wilson).

FIG. 2. *Austroablepharus kinghorni*, type species for the genus, with characteristic stripes and an orange tail; Durham Downs, Queensland (Image: Steve Wilson).

as containing three species: *P. reginae, P. tenuis* and *P. kinghorni*.

An additional two species, *P. naranjicaudus* Greer, Fisher & Horner 2004 and *P. barrylyoni* Couper, Limpus, McDonald and Amey 2010 have since been described and *Proablepharus* is currently recognised as a genus of five species (Cogger 2014, Wilson & Swan 2010). In appearance, these are easily separated into two groups: the small drab, practically patternless species (*P. reginae*, Fig. 1; *P. tenuis*) and the larger, distinctively striped species (*P. kinghorni*, Fig. 2; *P. barrylyoni, P. naranjicaudus*). Using both genetic and morphological data, we herein recognise these two groups as generically distinct. *Proablepharus reginae* is the type species for the small, patternless group and we here describe the large, striped group as a new genus, *Austroablepharus*, with *A. kinghorni* as the type species.

METHODS AND RESULTS

Genetic data. The phylogeny presented herein comes from a current analysis of exon data across Australian eugongylid skinks (Bragg *et al.*, in prep.). Here we just present a summary of the methods and results for the clade containing skinks currently assigned to *Proablepharus*. The tree presented (Fig. 3) is a concatenated phylogeny based on 1107314 base pairs of unphased exon nDNA data across 115 individuals of the species listed (with less than <10% missing data among species). The method for gathering the exon data, in-solution exon capture, is described in Bragg *et al.* (2016). The tree is constructed using a maximum likelihood approach in RAxML (8.2.3, Stamatakis 2014) based on the rapid bootstrap algorithm, a random starting tree, the GTRGAMMA model and 100 bootstrap replicates. In addition, a summary multispecies coalescent analysis using ASTRAL-II (4.7.9, Mirarab & Warnow 2015) supported the same nodes with 100% support, based on maximum likelihood gene trees also run in RAxML.

The phylogeny contains *P. reginae* (n = 8), *P. tenuis* (n = 26) and *P. kinghorni* (n = 4), but does not contain *P. naranjicaudus* and *P. barrylyoni* because tissue samples are not available for these two species. Our analyses of the genetic data retrieved a scheme of relationships in which the three species sampled were not monophyletic. *Proablepharus kinghorni* is more closely related to *Acritoscincus* and *Morethia* than it is to the clade containing *P. reginae* and *P. tenuis*. Support values for these relationships are very high, in all cases being 100% support from multispecies coalescent analysis and maximum likelihood (Fig. 3). The relationships shown here are supported by the broader species tree analysis across the Australian eugongylid skinks (Bragg *et al.*, in prep.).

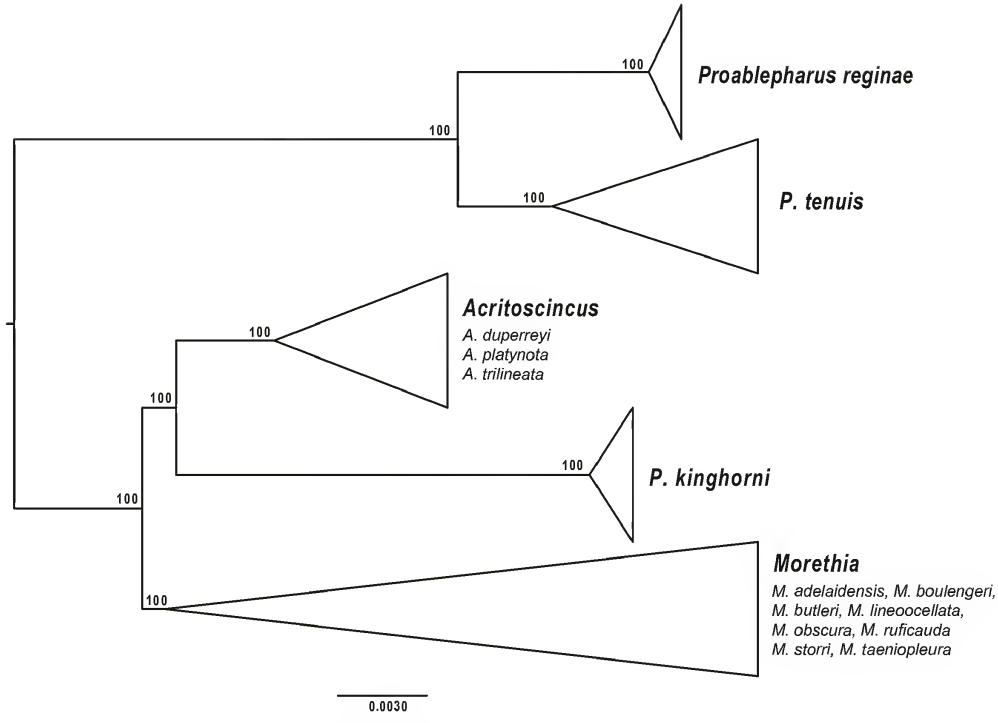

FIG. 3. An exon nDNA phylogeny of the eugongylid clade containing *P. reginae*, *P. tenuis* and *P. kinghorni* (now *Austroablepharus kinghorni*) and allied skink genera. See text for details on data and analysis.

Morphological data. The '*kinghorni* group' are most readily separated from *Proablepharus* by their larger size (SVL 45–51 mm *vs* 32–41 mm), a tendency for fewer midbody scale rows (20–24 *vs* 22–28), elevated paravertebral scale and presacral vertebrae counts (55–67 *vs* 52–57 paravertebrals; 30–36 *vs* 27–31 presacrals), fused frontoparietals (*vs* divided in *P. reginae* and *P. tenuis*, although the latter can occasionally also have a partly or fully fused condition), and keeled or mucronate subdigital lamellae (for *kinghorni* and *naranjicaudus vs* not keeled in *P. reginae* and *P. tenuis*) (Table 1). There are also distinct pattern differences, with adults of the '*kinghorni* group' exhibiting dark longitudinal stripes (present but less distinct in large, duller specimens) *vs* adult *P. reginae* and *P. tenuis* drab and practically patternless, and adults of the '*kinghorni* group' having obvious red/orange tail pigmentation (*vs* brown in adult *P. reginae* and *P. tenuis*; these two species have red tails as juveniles but the colour is lost with age; Greer 1980) (Table 1).

Assertions below regarding the polarity of the morphological characters uniting the '*kinghorni* group' follow Fuhn (1969) and Greer (1979, 1983). The fused frontoparietals in the '*kinghorni* group' are interpreted as a derived character state (Greer 1979), as are the keeled or mucronate (i.e., ending in a short sharp point) state of the subdigital lamellae (Greer 1979) in *kinghorni* and *naranjicaudus*. The polarity of the lamellae condition of *barrylyoni* is at this time unclear until the phylogenetic relationships among members of the '*kinghorni* group' are resolved. The modal (and primitive) number of presacral vertebrae for skinks with well-developed limbs is 26 (Hoffstetter & Gasc 1969; Greer 1983). Upward shifts from this state, marked by a reduction in limb length relative to body length, are considered progressive derivations (Greer 1983). Hence, the condition is derived for both *Proablepharus* and the

TABLE 1. Characters separating the small brown *Proablepharus* spp. from the larger, striped *Austroablepharus* species.

Character	*Proablepharus reginae*	*Proablepharus tenuis*	*Austroablepharus kinghorni*	*Austroablepharus barrylyoni*	*Austroablepharus naranjicaudus*
SVL (mm)	41	32	45	51	46
Presacral vertebrae	27–31	28-31	31–33	32–36	30–33
Paravertebral scales	52–57	53	55–64	58–67	58–64
Midbody scale rows	24–28	22–26	20–22	21–22	21–24
Frontoparietals	divided	divided, partially or fully fused	fused	fused	fused
Subdigital lamellae	not keeled	not keeled	finely keeled	not keeled	mucronate
pattern	plain	plain	striped	striped	Striped
Position of dark pigment on body scales	central	central	lateral edges	lateral edges	lateral edges
Adult breeding male tail colour	brown	brown	orange flush	orange flush	orange flush

'*kinghorni* group' but more so in the latter, more elongate, genus.

The differences in morphology between *Proablepharus* (*P. reginae, P. tenuis*) and the larger, striped species of the '*kinghorni* group' (*kinghorni, barrylyoni, naranjicaudus*) are supported by the genetic groupings retrieved, at least to the extent of the species included in the genetic study. The '*kinghorni* group' is distinguished from its sister genus, *Acritoscincus*, by the condition of the lower eyelid: immovable (preablepharine) *vs* movable. It is distinguished from *Morethia*, its next closest relative, by the condition of the supraocular/supraciliary contact: the primitive condition in the '*kinghorni* group' where the supraciliaries form a relatively straight-edged line of contact with the supraoculars *vs* a derived modal condition in *Morethia* where the supraciliaries are interdigitated with the supraoculars (Greer 1980). The species in the '*kinghorni* group' are more elongate than *Morethia*, as expressed by the higher number of presacral vertebrae (30-36 *vs* 27-31; data from Greer 2007) and hence this is regarded as a derived character state that distinguishes the '*kinghorni* group' from *Morethia*.

NEW GENUS

Austroablepharus gen. nov.

Suggested common name. Grassland Striped Skinks.

Type species. *Austroablepharus kinghorni* (Copeland, 1947)

Species. *A. kinghorni* (Copland 1947), *A. naranjicaudus* (Greer, Fisher & Horner 2004), *A. barrylyoni* (Couper, Limpus, McDonald & Amey 2010).

Etymology. Austro for Australia and ablepharus referring to an immovable lower eyelid that is partially fused to the upper eyelid to form a permanent spectacle.

Diagnosis. A genus of small skinks (adult SVL ≤ 51mm) with pentadactyl limbs, ≤ 24 midbody scale rows, ≥ 55 paravertebral scales, and ≥ 30 presacral vertebrae. Limbs narrowly to widely separated when adpressed. Supranasals absent and nasals undivided; prefrontals large, in contact or narrowly separated; eye moderate-sized with lower eyelid immovable, partially fused to upper eyelid to form a permanent spectacle but with a distinct slit between the lower eyelid and the supraciliaries (preablepharine); frontoparietals fused; interparietal free or fused; ear opening very small; parietals in contact; body pattern consisting of alternating

pale and dark stripes (each dorsal body scale with a pale centre and dark lateral edges); adult tail colouration red/orange.

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A review of the Water spider family Pisauridae in Australia and New Caledonia with descriptions of four new genera and 23 new species

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ABSTRACT

The family Pisauridae for Australia and the western Pacific is revised. The Australian fauna includes *Dolomedes, Megadolomedes, Hygropoda, Perenethis, Dendrolycosa* and *Inola* along with 3 new genera, *Tasmomedes*, gen. nov., *Ornodolomedes*, gen. nov., and *Mangromedes*, gen. nov. *Dolomedes* in the region includes 16 species. four of which are known – *Dolomedes facetus* L. Koch, 1876, *Dolomedes albicomus* L. Koch, 1867, *Dolomedes instabilis* L. Koch, 1876 and *Dolomedes flaminius* L. Koch, 1867– plus 9 that are new: *Dolomedes vicque* sp. nov. from Victoria to Queensland, *Dolomedes briangreenei* sp. nov. and *Dolomedes venmani* sp. nov. in New South Wales and Queensland, *Dolomedes alexandri* sp. nov., from the Australian Capital Territory, *Dolomedes pedder* sp. nov. and *Dolomedes lizturnerae* sp. nov. from Tasmania, *Dolomedes wollemi* sp. nov. from New South Wales, *Dolomedes mankorlod* sp. nov. from the Northern Territory, *Dolomedes karijini* sp. nov. from Western Australia. Of those, *Dolomedes flaminius* remains the most perplexing as no further material has been located from the Brisbane area from which it putatively came prior to 1867; the locality is presumed wrong. *Dolomedes stilatus* Karsch, 1878 is a synonym of *Perenethis venusta* L. Koch, 1878. *Dolomedes habilis* Hogg, 1906 is a junior synonym of *Dolomedes instabilis*. *Dolomedes chroesus* Strand, 1911 is removed from the fauna of Australia because of misidentifications. The newly rediscovered *Dolomedes eberhardarum* Strand, 1913 from Tasmania and Victoria is transferred to the new genus, *Tasmomedes*. A new species of *Megadolomedes, Megadolomedes johndouglasi* is described from Tasmania and Victoria; *Megadolomedes trux* Lamb, 1911 is restored as the northern relative of *Megadolomedes australianus* (L. Koch, 1865); *Megadolomedes nord* sp. nov. is described from Cape York. *Nilus kochi* Roewer, 1951 is rediscovered in mangroves in Queensland and with a new species from the Northern Territory (*Mangromedes porusus* sp. nov.), is transferred to *Mangromedes*, gen. nov. A new genus, *Ornodolomedes*, is described in which the spiders hunt freely at night on leaves on rainforest and closed eucalypt forest; the spiders have bold carapace and abdominal patterns. The genus includes 10 new species. from Queensland, *Ornodolomedes mickfanningi* sp. nov., *Ornodolomedes benrevelli* sp. nov., *Ornodolomedes gorenpul* sp. nov., *Ornodolomedes yalangi* sp. nov., *Ornodolomedes nebulosus* sp. nov., *Ornodolomedes xypee* sp. nov. and *Ornodolomedes marshi* sp. nov.; *Ornodolomedes staricki* sp. nov. from Victoria; from Western Australia, *Ornodolomedes nicholsoni* sp. nov., and *Ornodolomedes southcotti* sp. nov. from South Australia. In *Dendrolycosa,* the male of *Dendrolycosa icadia* (L. Koch, 1878) is described for the first time and one new species, *Dendrolycosa kakadu* sp. nov. is described from the Northern Territory. *Dendrolycosa yuka* Jäger, 2011 is considered African, not Australian. The male of *Hygropoda lineata* (Thorell, 1881) is described for the first time. The widespread species *Perenethis venusta* L. Koch, 1878 is described and figured and a diagnosis of *Inola* is provided. The New Caledonian fauna includes 3 species of *Dolomedes (Dolomedes titan* Berland, 1924, *Dolomedes neocaledonicus* Berland, 1924, *Dolomedes lafoensis* Berland, 1924), *Dendrolycosa icadia, Bradystichus* Simon, 1880 and a new genus, *Caledomedes,* gen. nov. Males and females of *Dolomedes titan and Dolomedes neocaledonicus* are redescribed and figured; *Dolomedes lafoensis* is reviewed. The New Hebrides *Do. naja* Berland, 1938 is is probably a sysnonym of *Do. facetus*. The misplaced lycosid *Anoteropsis flavovittata* is transferred to a new genus *Caledomedes*. The enigmatic *Bradystichus* is reviewed. All 11 genera and 39 species are diagnosed and mapped; all genera are keyed and keys to species of genera with more than two species are provided. ❐ *Taxonomy, Morphology, Distribution, New Species, Pisauridae.*

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Spiders of a number of families are strongly associated with water, from the intertidal mygalomorph *Idioctis* (see Raven 1988), through intertidal araneomorphs of the family Desidae (*Desis, Paratheuma*), Anyphaenidae (*Amaurobioides*, see Ceccarelli *et al.*, 2016) to the Diving spiders (*Agryoneta aquatica* (Clerck 1757)) of the Cybaeidae.

Many araneomorphs build webs on or near water or even bind to the water's meniscus, e.g. *Tetragnatha* and *Nanometa*, Tetragnathidae (pers. obs, RJR). Some lycosids (e.g. *Lycosa lapidosa* (pers. obs.)) and sparassids (*Heteropoda* spp.) range readily off rocks onto the water surface (pers. obs, RJR) and both have taken, as prey, the Cane Toad (*Rhinella marina*) as well as native Australian frogs. In Tasmania, a female lycosid *Diahogna martensi* (Karsch, 1878) was noted hunting freely on small ponds (pers. obs, RJR). However, in Australia, perhaps the better known of the spider families associated with water, albeit in some cases loosely, are the Pisauridae which include one of Australia's largest spiders, *Megadolomedes trux* Lamb, 1911 (see *Megadolomedes australianus* (L. Koch, 1865) in Davies & Raven, 1980). Those giants of the waterways hunt from the underside of rocks and logs beside slow moving streams, as well as large man-made pipes. When disturbed or hunting prey, the giant female, several times the size of the tiny male, dives readily to the substrate where she remains for long periods (at least 30 minutes), her abdomen clothed in a silver cloak of air (pers. obs., RJR).

Pisaurids include spiders that hunt freely, like *Megadolomedes*, and also spiders that build sheet webs, e.g. *Inola* and *Dendrolycosa*. To date, only one genus, *Megadolomedes*, was considered endemic: however, the family was unrevised. The genus *Dolomedes* is cosmopolitan but several Australian genera (*Perenethis, Dendrolycosa, Hygropoda*) are also found in Asia. Maternal pisaurids are quickly recognised when they are seen carrying the egg sac in the chelicerae (Figs 1a, 17b). Like the Lycosidae, most have large eyes in the posterior eye row (Figs 2, 3a–h, 4a–h) and are considered sighted hunters; a reflective layer (tapetum) in the eyes strongly reflects light in the night. Despite the common name, Water Spiders, they can also be found long distances (kilometres) from standing water. However, the term "Nursery web spiders" is unchecked in a number of these genera; the only behaviour that remains true to all seems to be that of holding the egg sac in the chelicerae. Nevertheless, this usage of the term "Water spiders" is common in Australia and appears in the Atlas of Living Australia (www.ala.org.au) which derives its taxonomy from the Australian Faunal Directory (www.environment.gov.au/online-resources/fauna). Pisaurids, notably *Dolomedes* and *Megadolomedes*, are well known for their predation of fish and frogs (see detailed review by Nyffeler & Pusey 2014).

This is not a comprehensive revision, as it does not revise all collections, at least in Australia, or treat all genera exhaustively; some species were not described because they are known only from females. The classification, genera and groups are functional and informative. There is no indication that they are phylogenetic. The inclusion of highly divergent species in an otherwise morphologically conservative group substantially broadens the genus concept. The monophyly of most of the genera and species groups, with the possible exception of *Dolomedes*, is unequivocal. Some genera may well lie within others, in which case, a "parent" genus is potentially paraphyletic.

Brief introductions are given with each genus with only an overview initially.

To date, the Australian Pisauridae have included 7 genera and 16 species (World Spider Catalog, 2017): *Dendrolycosa* (2), *Dolomedes* (7/8), *Hygropoda* (1), *Inola* (4), *Megadolomedes* (1), *Nilus* (1), *Perenethis* (1). Davies (1985) listed only 14 species and did not include *Dendrolycosa kochi* Simon, 1898 but included the Indonesian *Dolomedes chroesus* Strand, 1911. In Australia, the family has been unrevised, save for Davies & Raven (1980), Davies (1982), and Tio & Humphrey (2010).

Although few species of *Dolomedes* have been described from Australia, they seem to be a focal point of historical challenges: the oldest true *Dolomedes, Dolomedes flaminius* has not been relocated at the type locality and may not have

been from Australia (see Remarks of *Dolomedes flaminius*); the male syntype of *Dolomedes facetus* (from Rockhampton) was considered lost and subsequently a mismatched male from New Guinea was described by Chrysanthus (1967). Also, the holotype female of *Dolomedes instabilis* is lost. The epigynes, colour and body patterns of a number of Australian *Dolomedes* species described here are all very similar.

MATERIAL AND METHODS

Abbreviations. AER, anterior eye row; AME, anterior median eyes; ALE anterior lateral eyes; c. a, the often chelate apophysis retrolateral on the median apophysis; fe., female; ITC, inferior tarsal claw; juv., juvenile; ma., male; MOQ, median coular quadrangle; penult., penultimate; PER, posterior eye row; PLE, posterior lateral eyes; PME, posterior median eyes; RCH, retrocoxal hymen, a pallid unsclerotised zone retrolaterally on coxa I, used by Raven *et al.* (2002); STC, superior or paired tarsal claw. Palp terminology follows Silva & Griswold (2013b): BAC, basal apophysis of cymbium; DTP, distal tegular projection; CD, copulatory duct; CO, copulatory orifice; FD, fertilisation duct; RTA, retrolateral tibial apophysis; VTA, ventral tibial apophysis. The view RTAmax, for the male palp presents the RTA at its maximal width; often the RTA when viewed laterally is not most informative. Additional Terms: the caput "shoulder" is the narrowing of the carapace to form the caput; the dorsal and ventral lobes on the RTA are termed upper and lower (i.e. relative to a normally orientated palpal tibia) to avoid misunderstanding that they are not on the dorsal and ventral faces of the tibia. Cheliceral dentition is presented as 3p, 4r indicating three teeth on the promargin and 4 on the retromargin. The term "distal" denotes a character on the tip of the structure whereas "distal" refers to the distal half of the structure; equally, "basal" is used to refer to the basal half.

Eyes (Figs 2, 3 a–h, 4a–h). The width or length of eye rows is measured in a transverse or longitudinal line, respectively. The relative width of the eye group is given both through the PLE centres and through the mid-length of the eye group where that line intersects with a line joining the outer edges of the ALE and PLE (Fig. 2); equally, the position of the eye group in relation to the "shoulder", the concave narrowing from the carapace to caput, is given through the centres of the PLE. The extent of the curvature of the AER and PER are given as a percentage of the overlap of the two lines given by the extent to which a line across the anterior edge of the posterior eye of the respective rows overlaps with the anterior eyes of the row (Fig. 2). Eye measurements are not given in millimetres but eyepiece graticule units. MOQ and OQ are viewed from above. The length of the male palpal tibia and cymbium are taken through the mid-line of each. Eye row measurements and interspaces are taken through the diameters of the *Eyes.* Terminology of eye rows in spiders with a strongly recurved PER are confusing because row may be so curved that the eye extents do not overlap and that form two rows. PER overlap refers to the extent, from above that the two rows overlap (Fig. 2). Thus, zero overlap indicates the PER are two lines; 50% means the anterior edge of the PLE cuts the the middle of the PME.

Overall shape of epigyne (Fig.12e) is measured from the anterior extent of the lateral lobes to the posterior extent of the epigyne and the width is taken from the widest extent of the lateral lobes. The relative extent of the median field is taken from the point at which the scape begins to the posterior extent of the epigyne.

Leg measurements are given in the description as (leg) 1: femur, patella, tibia, metatarsus (absent in palp), tarsus, total. All but *Megadolomedes* females were measured using an eyepiece graticule; large females were measured with dial callipers. Spine counts on lateral and ventral surfaces are dependant on the angle of viewing; hence, absolute differences in, for example, the ventral count on metatarsi III and IV should not be taken as significant as in some cases a ventrolateral spine may have been scored as lateral in one case and ventral in another.

Institutions: AMS, Australian Museum, Sydney; ANIC, Australian National Insect

Collection, CSIRO, Canberra; BMNH, Natural History Museum, London; MCSN, Museo Civico di Storia Naturale Giacomo Doria, Genoa, Italy; MNHN, Museum National d'Histoire Naturelle, Paris; MV, Museum of Victoria, Melbourne; QM, Queensland Museum, Brisbane; SAMA, South Australian Museum, Adelaide; TMAG, Tasmanian Museum and Art Gallery, Hobart; WAM, Western Australian Museum, Perth. Localities and collectors: Ck, Creek; Is., Island; NP, National Park; QM party, Queensland Museum Terrestrial Biodiversity staff; Rd, Road.

Digital photographs were taken with either a Leica DFC 500 and the image stacking software program Zerene or a Nikon Coolpix 880 or Nikon Coolpix 5400, hand-held on the eyepiece of a Zeiss Stemi SV11 stereomicroscope or Leica SZ, resolution being 3 and 5 megapixels respectively. Drawings were drawn with a camera lucida on a Zeiss Stemi SV6. Scanning electron micrographs were done on a Hitachi S530 or a Hitachi TM1000.

Material examined, both types and otherwise, refer to the first author's examinations. Coordinate of localities for which those were not recorded on collecting are taken from Google Earth and rounded to the near 10 minutes and given in square parentheses; their accuracy should thus be taken at best as ±10 minutes.

Here, all evident morphological characters have been used to associate males with conspecific females. Although species are described based only upon males, it seemed unwise to describe females without associated males. Given that up to four *Dolomedes* species can occur in sympatry, all with similar abdominal and cephalic patterns, the potential for mismatching males and females is high.

MORPHOLOGY

Characters in *Dolomedes.* Carico (1973) found a number of characters of diagnostic value in Nearctic *Dolomedes*; all were checked here. Of those, no males of the Australian *Dolomedes* treated here showed any modifications on ventral femur IV, the carapace (lateral) profile in all species was consistent, being higher behind and sloping gradually to the front. The cephalic and dorsal abdominal patterns were consistent in most species, save for *Dolomedes facetus* and *Dolomedes flaminius*, in which the patterns on the carapace and abdomen are more distinctive. Abdominal pattern did preserve best in specimens with a distended abdomen unless preserved in 100% ethanol when shrinkage was strong (e.g. Fig. 33a, *Dolomedes lizturnerae* sp. nov., male). However, some females of some species (e.g. *Tasmomedes eberhardarum (*Strand 1913), *Dolomedes instabilis*, *Do. lizturnerae* sp. nov.) but usually not the males, except for *T. eberhardarum,* have a dark field on the ventral abdomen with two pairs of pallid lines (Fig. 38b, c, e). The vagaries of different preservations, different transporting after preservation, and in some cases damage either during capture or through capture (e.g. egret regurgitation) reduced the efficacy of the character.

The biggest challenge in this work was matching conspecific males and females of *Dolomedes*. This was made more complex by the sympatric occurrence of up to four similar species with similar epigynes (see below) and no discovered characters allowing the alignment of the male and conspecific females. Molecular methods should be the modern panacea. However, much of the material was collected into a mixture of ethanol, glycerol, water, and acetic acid, the latter two being most damaging to the successful extraction of DNA. A sound molecular approach will cast invaluable light on the relationships of the various genera and the vexatious question about, for example, whether *Megadolomedes* is merely an apomorphic clade within *Dolomedes.* To resolve such a question, a study of many species, not just those from Australia would be necessary. Hence, for new species, only holotypes (males) are designated as types, with females being listed simply as material examined.

Females of *Dolomedes*. The association of males with their putatively conspecific females was based upon a number of criteria. First, if a good collection was made in an area, e.g. Lake Broadwater (south-east Queensland), and only one species was taken they were assumed to be

matching. Often, *Do. facetus* is present at most localities; males and females are among the smallest *Dolomedes* with quite ornate abdominal patterns and the palp and genitalia quite distinctive. This species then can be readily eliminated as a potential conspecific of larger *Dolomedes*. In some cases, three species (apart from *Do. facetus)* with similar females are found in the same area or may be taken in sympatry. In this case, species with the most different male palp and different female epigyne (e.g. *Dolomedes venmani* sp. nov.) are associated.

Penultimate females. A lesser challenge was the recognition of penultimate females in which the spermathecal ducts had substantively developed. In one case, a very large penultimate female *Dolomedes* showed primordia (see also Sierwald 1997).

Australian male *Dolomedes* of the *Dolomedes albicomus* group show a character not reported in other *Dolomedes* species world-wide, save for *Dolomedes nigrimaculatus* Song & Chen, 1991: with the exception of the cymbium, the palp is very long with often the patella but always the tibia being clearly longer than the cymbium (e.g. Fig. 12b). In all other species or at least those presently known and included in the genus *Dolomedes*, the tibia is shorter than cymbium.

Spines. The leg spination, position and number of the spines treated here is remarkably consistent and hence only limited data are given. However, two spine characters were noted which seemed informative. The patella triad is one mid-point prolateral spine, one basal and one distal spine dorsally. The second character is the number of dorsal spines on the dorsal palpal femora; the widespread spination pattern is fe p1d1.1.1.2.r1; i.e. three spines in a row dorsally followed by a distal pair (Fig. 21a, arrows). In some *Ornodolomedes*, gen. nov., species, only one or two spines occur dorsally basal to the distal pair.

Male Palp. The overall shape and position of sclerites of the male palp across *Dolomedes, Megadolomedes. Ornodolomedes*, gen. nov. *Mangromedes, gen. nov., Caledomedes, gen. nov.* are highly consistent with the L-shaped tegulum with DTP; the fulcrum, conductor and median apophysis are all similar in overall shape and position. In the pisaurine genera reported here, the conformation is quite different, except possibly in *Hygropoda* in which the tegulum is U-shaped, i.e. retrolateral edge is extended anteriorly. However, the somatic morphology, as well as the carapace and abdominal pattern are consistent within each genus.

Epigyne. Carico (1973), following Carico & Holt (1964), used a number of epigynal characters to help identify species of Nearctic *Dolomedes*; some of those are used here, namely, maximum length to width (i.e. the ratio) of the epigyne and extent of the scape/median field. Many species of Australian *Dolomedes* have very similar epigynes with two curving lateral lobes and a narrow median septum joined to a broad median field. The relative shape of the epigyne remains relatively stable across species, as does the relative extent of the median septum. In some species, a pair of soft "hooks" (Figs 16g, 19a) arise from the median field; in others, a soft median cone is present. In one species at least, the median field extends for the length of the epigyne. However, internally, several different groups of the ducts are evident. Most widespread are a pair of similarly sized, short broad CD's directed diagonally outwards with the relative length, size, direction and position of the posterior duct varying between species. Less common are long slender sinuous ducts diagonally directed or spiralled ducts (Fig. 38i).

The relative length to width (overall shape) of the epigyne is easily quantifiable, as is the length of the septal area; the species "groups" formed by the combination have divergent shaped spermathecae, so they are not highly informative in isolation.

FAMILY PISAURIDAE

Description. Pretarsal fracture present (*Megadolomedes, Ornodolomedes,* gen. nov., *Bradystichus, Inola, Perenethis, Dendrolycosa*) or absent (*Dolomedes, Tasmomedes,* gen. nov., *Caledomedes*, gen. nov., *Mangromedes*, gen. nov., e.g. Fig. 7d, inset); retrocoxal hymen not evident in any examined Pisauridae. Three claws; teeth

present or absent on third claw; claw tufts absent. Cribellum absent. Eyes in 2–3 rows, 4.4 or 4.2.2, with a strongly recurved PER with no overlap of the eyes. Male palp with retrolateral tibial apophysis, bulb with conductor, fulcrum and median apophysis. Spines: on ventral tibiae and metatarsi I, II slender, juxtaposed, not strong opposed pairs, as in e.g. Zoropsidae. Females carry eggs in chelicerae.

Subfamilies. At present, two subfamilies, Thalassiinae and Pisaurinae, are recognised (Zhang, Zhu & Song 2004); however, morphologically, the defense for the groups is weak.

Murphy & Roberts (2015: 144) newly divided the Pisauridae into the Dolomedinae, Pisaurinae and Eurychoerinae initially based on the absence or presence (latter two subfamilies) of the pretarsal fracture. However, in so doing, they set aside many strong similarities in the bulbs in the then separated groups, as shown in in the strongly *Dolomedes* like palp of *Bradystichus* which respectively lack and possess a pretarsal fracture. Also, of the 48 pisaurid genera listed, only 9 genera (those illustrated) were placed in the three subfamilies so proposed. Significant here is that *Dendrolycosa* was placed in the Eurychoeinae. Abdominal setae types also supported their groups and they hypothesised that the brachiate setae, present only in the Pisaurinae and Eurychoerinae (i.e. those with the pretarsal fracture), would be "a hindrance when diving into water for prey". Of the Australian genera with a pretarsal fracture, only *Megadolomedes* hunts beside and dives into water and of those in which it is absent, *Caledomedes* gen. nov., alone does not hunt in water.

Remarks. One of the characters putatively differing between the Pisauridae and Lycosidae is the presence of teeth on the third claw. This was consistently checked and, in many cases, such teeth are recorded as absent but the tooth, if present, it often very slender and difficult to discern from bristles around the claws. Equally, teeth are present on the third claw of spiders of the lycosid genus *Venonia* (pers. obs.). Hence, in practice, the character is not useful at the family level.

Although some trechaleids have tarsi pseudosegmented, the character is by no means universal in the family and is presumably apomorphic within the group. The male palpal configuration of the pisaurid genera with pseudosegemented tarsi (*Hygropoda* and *Megadolomedes*) is very similar to that in *Dolomedes*, whereas the male palp of trechaleids are basically that of a lycosid but with a tibial apophysis (pers. obs.).

KEY TO GENERA OF THE WESTERN PACIFIC

1. MOQ on long gentle slope (Fig. 5a) ..... *Perenethis*
– MOQ on steep slope (Fig. 5b–h) 2

2. (1). Tarsi pseudosegmented, curved (Fig. 7e) 3
– Tarsi not pseudosegmented, straight (Fig. 7a–d) 4

3. (2). Abdomen long and slender (Figs 77, 79a), green in life (Fig. 77), males and females small (carapace length *ca.* 3 mm) ..... *Hygropoda*
– Abdomen short, cordate, earth coloured (Fig. 1a), never green in life, males small and females very large (carapace length 6–10 mm) ..... *Megadolomedes*

4. (2). Ventral abdomen with dark median field with pale, red or orange spots centrally (Fig. 71b); dorsally abdomen often mud-encrusted; males with scopula on prodorsal cymbium (Fig. 71a, b; only New Caledonia) ..... *Bradystichus*
– Ventral abdomen pallid without strong ventral pattern; dorsal abdomen never mud-encrusted, no scopula on cymbium of males (Australia, New Caledonia) 5

5. (4). Pretarsal fracture present (Fig. 6a) ... 6
– Pretarsal fracture absent (Fig. 7c, d) 7

6. (5). AER straight (Fig. 4b) ..... *Inola*
– AER clearly recurved (Fig. 73g); abdominal pattern with anterior medial dark "tongue" with waist (Fig. 73g) ..... *Dendrolycosa*

7. (5). AER narrow, no wider than second row

(MOQ back width; Fig. 68c)...*Caledomedes*

– AER wider than second row (MOQ back width; Fig. 3c) 7

8. (7). Spines on ventral tibiae and metatarsi I, II long, extents overlapping (Fig. 7f); legs slender.....9

– Spines on ventral tibiae and metatarsi I, II short, extents not overlapping (Fig. 7a–c); legs stout.....10

9. (8). Males with deeply incised RTA (Figs 65b, 66d); females with extensive epigynal "wings" (Fig. 65c–e); found in intertidal zone, usually in mangroves.....*Mangromedes*

– Males with simple short RTA (e.g. Figs 46a, 53b–e, 57a, 63a, d, g, j); female epigyne ovoid, without wings (e.g. Figs 46c, 49c, 51c, 59e, 60b)..... *Ornodolomedes*

10. (8). Male palp with elongate cymbium (Fig. 38f, g); female with spiralled spermathecae (Fig. 39i); Tasmania, Victoria..*Tasmomedes*

– Male palp with short cymbium (e.g. Fig. 10a); female with short spermathecae confined posteriorly (Figs 10g, 14b); Australia-wide .....*Dolomedes*

Pisauridae Simon, 1890

***Thalassiinae* Simon, 1898**

Included genera (following Zhang, Zhu & Song, 2004): *Dolomedes* Latreille, 1804, *Nilus* O.P. Cambridge, 1876 (senior synonym of *Thalassius*), *Hygropoda* Thorell, 1895, *Megadolomedes* Davies & Raven, 1980, *Mangromedes*, gen. nov., *Ornodolomedes*, gen. nov., *Caledomedes*, gen. nov., *Tasmomedes*, gen. nov., *Bradystichus* Simon, 1884, *Qianlingula* Zhang, Zhu & Song, 2004, *Sphedanus* Thorell, 1897.

HISTORY OF *DOLOMEDES*

Two species, *Dolomedes albicomus* and *Dolomedes flaminius*, were described by L. Koch (1867) from south-east Queensland and figured in L. Koch (1876) in which were also described *Dolomedes facetus* from Queensland and *Dolomedes instabilis* from western New South Wales. A fifth species, *Dolomedes elegans* L. Koch, 1876 proved to be misplaced and was transferred to *Nilus* by Simon (1898) but the original combination was preoccupied (by *Dolomedes elegans* Taczanowski, 1874) and replaced with *Nilus kochi* by Roewer (1951) (see *Caledomedes* gen. nov.) Chrysanthus (1967) figured a male and female ascribed to *Dolomedes facetus* from New Guinea. *Dolomedes stilatus* Karsch, 1878, described from Western Australia, is here transferred to *Perenethis*. Strand (1911) described a female as *Dolomedes chroesus* from Indonesia which was redescribed from a male by Chrysanthus (1967) and, based on material in the Queensland Museum. Davies (1985) considered the species to be also in Australia but no description or figures were given. The World Spider Catalog (2017) lists the species in New Guinea, as described. Soon after, Strand (1913) described a male as *Dolomedes eberhardarum* from Victoria. Until now, no further material of this species has ever been reported in Victoria but the species is here reported widespread in heath in Tasmania.

Significantly then, with the exception of the *Megadolomedes*, the genus *Dolomedes* has remained unrevised in Australia and perhaps this is best exemplified by the only two specimens taken in the past 110 years of *Dolomedes eberhardarum* from Victoria, Australia's most densely populated state by a factor of 2.7.

Vink & Dupérré (2010) revised the genus *Dolomedes* in New Zealand, looking at over 350 adults and across highly comprehensive geographic extent. With the help of one mitochondrial (CO–1) and one nuclear gene (Actin5C), they examined the divergence and introgressions in that fauna. For all of New Zealand, they admitted only four species of *Dolomedes* and the results are used critically herein.

Given that some Australian species, e.g. *Dolomedes facetus* and *Dolomedes chroesus*, are currently listed at least notionally from elsewhere in the Pacific, the geographical scope of this work was expanded to also include New Caledonia, where extensive collections have been made. Thus, the New Caledonia *Dolomedes*, *Dolomedes lafoensis* Berland, 1924, *Dolomedes neocaledonicus* Berland, 1924, and *Dolomedes titan* Berland,

1924, were reviewed to ensure no Australian species considered new was among them.

Equally, *Anoteropsis flavovittata* Simon, 1880, which Vink (2002) found to be misplaced in the Lycosidae, raised questions about the validity of proposed new Australian species and genera and is thus included here. For completeness, the bizarre mud-wallowing New Caledonian pisaurid genus, *Bradystichus*, is also included.

This work makes no pretence of being a full revision. The scope has been to treat all of the Australian pisaurids in the QM collection and those in other museums that bore upon the issues that needed to resolve the Queensland species and the previously described species. Hence, it is a review. The work began with the offer of a new species of *Dolomedes* for the World Science Festival founder, Dr Brian Greene. It quickly became apparent that the scope had to be extended, as noted above, to ensure that senior synonyms of the new species were not described from outside of Australia.

The order of treatment of *Dolomedes* starts in Queensland with the most widespread species, followed by shorter range species from other states.

Dolomedes Latreille, 1804

Dolomedes Latreille, 1804: 135. Type species. *Araneus fimbriatus* Clerck, 1758 by subsequent designation of Walckenaer (1805: 16); Rainbow, 1911: 263; Davies, 1985: 102; 1 ma., 1 fem., *Dolomedes fimbriatus*, B. Baehr European collection, det B. Baehr, examined.

Diagnosis. Males of *Dolomedes* are most similar to those of *Tasmomedes* gen. nov., from which they differ by the short cymbium, conductor, and fulcrum; females differ in the non-spiralled spermathecae.

Description. Carapace in lateral view highest posteriorly, sloping down to eye region (Fig. 5g). PTF absent. Eyes of PER larger than those of AER. Caput saddle posterior to PLE. AER width less than PLE–PLE. Males and females of similar size. Male palp with L-shaped DTP, distal conductor, and cymbium ventral, and retroventral processes basally. Males have tarsus I much longer than II or IV; in females, tarsus I is only slightly longer than II. Spines on ventral tibia and metatarsi I, II short, not overlapping (Fig. 7a–c). Diurnal and nocturnal spiders hunting freely beside creeks usually with at least first pair of legs in water; also found under rocks in creek beds diurnally.

Distribution. World-wide, excluding Antarctica.

Australian species. *Do. albicomus*, *Do. facetus*, *Do. flaminius*, *Do. instabilis*, *Do. briangreenei* sp. nov., *Do. vicque* sp. nov., *Do. alexandri* sp. nov., *Do. lizturnerae* sp. nov., *Do. wollemi* sp. nov., *Do. mankorlod* sp. nov., *Do. karijini* sp. nov., *Do. venmani* sp. nov.

***Dolomedes* world-wide.** Comparisons between *Dolomedes* species in different biogeographic regions have not yet been documented. However, the clypeus height in the male of *Do. raptoroides* Zhang, Zhu & Song, 2004 (CL:CW=1.17) (Silva *et al.* 2015, fig. 5) is only that from the lower edge of the AME to that of the PME, whereas in *Do. kalanora* Silva & Griswold, 2012 (fig. 5), (CL:CW=1.07) the eyes are quite remote from the clypeus which is as wide as the length of the MOQ (from front). Equally, the carapace of the latter is relatively wider than that of the former. Likewise, Vink & Dupérré (2010) showed a long clypeus in *Do. schauinslandi* Simon, 1889 (Vink & Dupérré, 2010, fig. 38) and a short clypeus in *Do. dondalei* Vink & Dupérré, 2010 (Vink & Dupérré 2010, fig. 3) and *Do. minor* L. Koch, 1876 (Vink & Dupérré 2010, fig. 34). Thus, although the genus is very consistent in genital morphology, there are probably informative differences somatically.

Australian species of *Dolomedes* can be readily divided into 5 groups based on the male palp: the *Do. albicomus* group always has the tibia longer than the cymbium and most species have a flange on the retrolateral side of the median apophysis. All other species have the palpal tibia at most as long as the cymbium and, within them, the *facetus* "group" (only *Do. facetus*, *Do. neocaledonicus* and *Do. flaminius*) have a large DTP and deeply incised RTA. The *Do. briangreenei* group includes *Do. vicque* and *Do. briangreenei*, both have a small DTP and a widely flared RTA that is multidentate. The *Do. albicomus* group includes *Do. albicomus*, *Do.*

instabilis, *Do. mankorlod*, *Do. karijini*, *Do. wollemi*, *Do. lizturnerae*, *Do. venmani*, as well as *Do. titan* in New Caledonia. The *Do. facetus* group includes *Do. facetus and Do. flaminius* in Australia, as well as *Do. neocaledonicus* in New Caledonia. The *Do. alexandri* group is monotypic.

KEY TO MALE *DOLOMEDES* AND *TASMOMEDES* IN AUSTRALIA AND NEW CALEDONIA

1. Palpal tibia clearly shorter than cymbium or at least equal and median apophysis not apically chelate (Figs 10a, 18a) 2
– Palpal tibia clearly longer than cymbium and median apophysis apically chelate (Figs 12b, 12a). 7

2. (1). Distal tegular process slender, digitiform, parallel-sided for mid-length (Fig. 22a). . . 4
– Distal tegular process large trianguloid (Figs 10a, 24a). 3

3. (2). RTA viewed retrolaterally two similarly long prongs (Figs 10e, 37d) 14
– RTA viewed retrolaterally with 3–4 short prongs (Fig. 24c) . . . . . *Do. pedder*

4. (2). Conductor extends past tip of DTP for half length of bulb (Fig. 38f, g) . . . . . *Tasmomedes eberhardarum*
– Conductor extends just past tip of DTP (Fig. 31a) 5

5. (4). Palpal tibia barrel-shaped, RTA small simple (Fig. 31a). . . . . *Do. alexandri*
– Palpal tibia coniform, widening distally, RTA flared, multilobed (Figs 16a–f, 20a, b) 6

6. (5). RTA retrolaterally, a long flared edge with single dorsal process (Figs 18a, b, 19e–h, 20a, b) . . . . . *Do. briangreenei*
– RTA retrolaterally, a long scooped trianguloid process with one apical prong flared and smaller subapical prongs (Fig. 16a–f) . . . . . *Do. vicque*

7. (1). Palpal tibia long straight (Fig. 12b) . . 8
– Palpal tibia bowed laterally (Figs 21b, 22a) . . . . . *Do. venmani*

8. (7). Palpal tibia very long, *ca.*1.40–1.80 times length of cymbium (Fig. 12b); retrolateral process of median apophysis distal and thick spiniform (Fig. 12a). . . . *D. albicomus*
– Palpal tibia shorter, ca. 1.00–1.38 times longer than cymbium (Fig. 13a), retrolateral process of median apophysis apical or absent (Figs 13a, 26a) 9

9. (8). Retrolateral process of median apophysis absent (Fig. 26a) . . . *Do. wollemi*
– Retrolateral process of median apophysis present. 10

10. (9). Retrolateral process of median apophysis above "neck" (Figs 27a, 32a). 11
– Retrolateral process of median apophysis below "neck" (Figs 28b, 36a) 12

11. (10). Retrolateral process of median apophysis apical making MA apex chelate (Fig. 32a) . . . . . *Do. lizturnerae*
– Retrolateral process of median apophysis hooked, just above neck (Fig. 27a) . . . . *Do. mankorlod*

12. (10). Retrolateral process of median apophysis beak-like (Fig. 28b). . *Do. karijini*
– Retrolateral process of median apophysis small, triangular (Figs 13a, c, 36a). 13

13. (12). Retrolateral process of median apophysis set well basal on neck; very large spiders (CL=*ca.* 12 mm); New Caledonia (Fig. 36a, b) . . . . . *Do. titan*
– Retrolateral process of median apophysis set apical on neck; large spiders (CL=*ca.* 7 mm); Australia (Fig. 13a, c) . . *Do. instabilis*

14. (3). RTA deeply incised (Figs 10b, 37b) . . . . . 15(14)
– RTA a long low ridge with upper lobe . . . . . *Do. flaminius*

15. (14). Abdomen dorsally with a pair of fine white stripes and spots, centrally with dark band (Fig. 8a) . . . . . *Do. facetus*
– Abdomen dorsally with continuous white band along edge and central band pallid (Fig. 37a); New Caledonia . . . . . *Do. neocaledonicus*

Dolomedes facetus L. Koch, 1876

(Figs 4c, d, 7a, 8a–d, 9a, b, 10a–j. Map 1a)

Dolomedes facetus L. Koch, 1876: 869, pl. 74, figs 5, 6; Chrysanthus, 1967: 423, figs 63, 64, (female); Rainbow, 1909: 274; Rainbow, 1911: 263; Davies, 1985: 103.

Dolomedes chroesus: Chrysanthus, 1967: 422, figs 62, 66, male, misidentified.

Material examined. Types. Queensland: lectotype (*Dolomedes facetus*, designated by Chrysanthus, 1967) fem., Rockhampton, ZMH MGH 6522. Paralectotypes: juveniles, same data as lectotype, ZMH; 1 ma., 2 fem., BMNH 19.9.18.5540–42; 3 females, 1 penult. male, juveniles, no further data, Museum Godeffroy, MV K13739–613743.

Other Material examined. Queensland: 1 ma., 1 fem., Carnarvon Station (CN3M1), 24.837°S, 147.623°E, 690 m, malaise trap in *Callitris* stand near damp edge with fords, 14 Dec 2010—15 Jun 2011, A. Zwick & Wilson, QMS107111; 1 fem., Ayr, 19°34′S, 147°27′E, 10 Jan 1974, V. Salanitri, QM S28788; 1 ma., 3 fem., Weatherstation Ck, 13°42′S, 143°17′E, 17 Mar 1979, K. McDonald, QM S67773; 1 ma., 4 fem., Hibbett Point, Weipa, 12°39′S, 141°53′E, 7 Feb 1975, R.J. Raven, QM S28846; 1 ma., Biloela, 24°24′S, 150°31′E, 21 Jan 1997, Department of Primary Industries, Biloela, QM S34561; 1 fem., Little Yabba Ck, Conondale Range, 26°36′S, 152°35′E, 14 Dec 1977, QM S67756; 1 ma., 1 fem., Fig Tree Pocket, Brisbane, 27°28′S, 153°03′E, 9 Nov 1972, V.E. Davies, QM S192; 1 ma., 1 fem., Blackdown Tableland, Stony Ck Falls, 23°48′S, 149°08′E, 1–6 Feb 1981, R.J. Raven, QM S67782; 1 ma., 1 fem., Proserpine, Deadman Creek, site XY17, 20°30′S, 148°33′E, open forest, night collection, 17 Mar 2008, R.J. Raven, QM S85987; 1 fem., Boondall Wetlands (BCC1), 27°20′S, 153°04′E, *Melaleuca* open forest, pitfall, 31 Mar–629 Apr 2004, QM party, QM S65571; 1 fem., Montville, 26°42′S, 152°54′E, Apr 1915, H.A. Longman, QM S67757; 1 ma., Taroom District, Boggomoss No 19, 25°25′S, 150°01′E, *Lophostemon*, night collection, 11 Nov 1996, P. Lawless, QM S37434; 1 fem., Boggomoss No 3, via Taroom, 25°26′S, 150°01′E, 12 Nov 1996, G. Thompson, QM S36878; 1 fem., Taroom District, Boggomoss No 21, 25°27′S, 150°03′E, hand collection, 11 Nov 1996, QM survey, QM S36939; 1 ma., 2 fem., Musgrave, (Merina Downs Rd), roadside, 19 May 1973, V.E. Davies, QM S52190; 1 fem., Marsupial Ck, E Croydon, bucket trap (elev.), 15 Mar–29 Jun 2002, J. Hasenpusch, QM S73819; 2 ma., Cedar Galleries, dam, Calliope, 23°59′S, 151°10′E, 27 Feb–1 Mar 2017, R. Raven, QM S108244; 1 fem., Moorehead R, 18 May 1973, V.E. Davies, QM S67723; 1 fem., Norman R xing, main rd S Normanton, 17°40′S, 141°05′E, Oct 1977, M. Archer, QM S67747; 1 ma., Toomba Homestead site, moist litter pockets, 19°58′S, 145°34′E, basalt ridge with *Brachychiton*, litter, 15 Feb 2007, R.J. Raven, QM S79252; 1 ma., 3 fem., Doboy, 17 Dec 1979, D. Seaton, QM S91004; 1 fem., 2 ma., Gatton, 21–23 Feb 1980, QM S91392; 1 ma., Coolibah camp, 28 Jul 2016, R. Raven, QM S104917; 1 fem., Berringtonia Lagoon, Cape York Peninsula, Jun 1982, QM S104923; 1 ma., Norman River, edge, Oct 1977 QM S104924; 1 ma., Kilcoy Creek, 27 Jul 1978, QM S104925; 1 fem., Almaden, Chillagoe district, 17°20′S 144°41′E, June–Sept. 1929, W.D. Campbell, AM KS117592; 1 fem., same data but, May 1929, W.D. Campbell, AM K59086; 1 fem., Nerina Downs, near Homestead, 20 May 1973 QM S104926; 1 fem., Springfield camp site near Mt Surprise, 31 Aug 1980 QM S104927; 1 fem., Cooloola, 13 Jul 1973, QM S104928; 2 fem., Mt Molloy, QM S1974, QM S104929; 1 fem., Cooktown, Feb 1975–Mar 1975, QM S104930; 1 fem., Lagoon 2 miles N ,of Moorehead River, 19 May 1973. QM S104931; 1 fem., Lake Broadwater near Dalby, 12 Feb 1984 QM S104932; 2 fem., Coen, 11 Mar 1979, QM S104933; 3 fem., 1 juv., Appel Channel, Mornington Island, 16°42′S, 139°11′E, 30 Apr 1960, N.B. Tindale, P. Aitken, SAMA NN13650–54. New South Wales: 1 fem., Carroll's Creek, above road bridge, 28°50′50″S 152°05′56″E, 4 May 2008, G. Theischinger, AM KS109227; 1 fem., Ryans Creek at Belle View, 33°37′58″S 150°07′11″E, 1 May 2007, S. Claus, AM KS119896; 1 fem., Careel Bay [33.6208° S, 151.3219° E], mangrove area, 4 Dec 1972, Australian Littoral Society, S. Ceggs, AMS KS; 1 ma., Gurley Creek at "Carrington", 29°39′25″S 149°36′59″E, 29 Mar 2010, D. Mawer, AM KS112416; 1 ma., Millie Creek at Ellematta, 29°48′45″S 149°32′31″E, 10 Feb 2001, D.K. McAlpine, AM KS109234; 1 ma., Darling River at Windmill, 30°01′46″S 146°02′22″E, 22 Mar 2007, G. Theischinger, AM KS119879; 1 ma., Namoi R at Namoi Farm, 30°21′16″S 149°47′17″E, 18 Mar 2009, G. Theischinger, AM KS110776; 1 ma., Wandalli Ck at Munda, 28°29′19″S 150°30′28″E, 4 May 2009, G. Theischinger, AM KS110778; 1 ma., Tulla Mullen Ck at Railway X-ing, 30°35′19″S 149°56′50″E, 17 Apr 2007, S. Jacobs, AM KS101391; 1 ma., 1 fem., juv., Lachlan River at Whealbah Rd, 33°39′32″S 145°14′54″E, 24 Jan 2011, C. Rush, AM KS115667; 1 ma., 1 juv., Bucklandbak Ck, Wexford, 18 March 2008, G. Theischinger, 30.9624°S, 148.69161°E, AM KS105156; 2 fem., St Marys [no further data), AM K3539. Northern Territory: 2 fem., Casuarina Coast Reserve, Darwin, 12°27′S, 130°50′E, 29 Mar 1982, per Darwin City Council, QM S67772; 1 fem., Kakadu NP, Magela floodplain, 1 May 1987, P.Dostine, QM S51192; 1 fem., Ellery Ck via Hermannsburg, 23°47′S, 133°05′E, 15 Mar 1995, R.J. Raven, QM S53461; 1 fem., Wildman Ra., Kakadu National Park, 4 May 1979, QM S104922; 1 ma., Melville Island, Pickertaramoor, 5 km W, Arnhem Land, 11°46′S, 130°52′E, 17 Jan 1990, M.J. Tyler, SAMA NN13649. Western Australia: 1 fem., Stewart R at "Kimbolton Station", Kimberley Ra., 16°44′S, 123°54′E, 15 Jul 1986, R. Leggett, G. Heidke, QM S67765. South Australia: 3 ma., 1 fem., Morris Creek Bore tail, Finniss Springs Station, Lake Eyre Basin, 29°25′40″S, 137°34′E, 29 Mar 1996, D. Niejalke, SAMA NN13577–81. Victoria: pen. ma., Churchill, Gippsland, 38°18′S, 146°26′E, 12 Aug 1993, R. de Souza-Daw, from dam, SAMA NN8727.

Diagnosis. The male palp of *Do. facetus* is very similar to that of *Do. flaminius:* the palpal tibia being slightly shorter (*ca.* 0.83) than the cymbium (Fig. 9a, b), the DTP is large and trianguloid with a similar prolateral basal mound (Fig. 9a), the median apophysis lacks the retrolateral vane (Fig. 9a) and the very long male palps of the *Do. albicomus* group (Figs 12a, 13a), the ventral abdomen lacks pattern and the dorsal abdomen has pallid spots and a median pallid zone. The difference between males of the two species is shown in the retrolateral view of the RTA which is a low ridge set distal in *Do. flaminius* (Fig. 24c) but a ridge with two long prongs set clearly predistal (Fig. 10b) in *Do. facetus*, the tibia (most noticeable in retrolateral view) is of similar width for its length in *Do. flaminius* but distinctly wider distally in *Do. facetus*, and the tegulum in the latter is longer, slender and clearly diagonal. Females of *Do. facetus* are unusual (if not unique) in the Australian region in the relatively short wide epigyne with roughly trianguloid ridges and the lateral lobes being strongly diagonal, posteriorly convergent with a small quadrate median field (Fig. 10f, h); internally, the CD is basally forming a figure 8 anteriorly then recurving back through a double fold to a more anterior FD (Fig. 9d). The male palp of *Do. schauinslandi* Simon, 1889 (see Vink & Dupérré, 2010) shows strong similarities to that of both *Do. facetus* and *Do. flaminius* in the large DTP but differs in the smaller RTA

In life, compared to most other *Dolomedes* species, males and females of *Do. facetus* are much lighter coloured on the carapace and legs and have quite a colourful abdominal pattern dorsally (Fig. 8a–d); males lack the broad white bands that flank the carapace as in other species.

Description. Male QM S107111. Carapace 5.36 long, 4.80 wide. Abdomen 4.80 long, 3.04 wide. Total, 10.16.

I: 6.72; 2.48; 6.48; 5.68; 3.28; 24.64. II: 6.64; 2.80; 6.00; 5.36; 3.04; 23.84. III: 6.00; 2.48; 5.04; 4.64; 2.72; 20.88. IV: 7.04; 2.48; 6.32; 6.64; 4.00; 26.48. Palp: 2.88; 0.88; 1.36; 1.92; 7.04.

Carapace orange brown with white haired midline; wide bands of white hairs on margins. Abdomen ostiate region orange with sinuous convergent lines forming four chevrons posteriorly and four pairs of white spots. Abdomen upper flanks with white band. Abdomen long tear-shaped. *Eyes.* Group width/headwidth=0.69 through PLE, 0.57 through mid-eye group. OQ front, back, long: 54, 85, 47. MOQ front, back, long: 32, 45, 26. AME: ALE: PME: PLE, 12: 10: 15: 16. PLE at mid-caput shoulder. AER with 30–40% overlap; PER in two lines well separated by ALE diameter. Chelicerae 2p, 4r. STC with *ca.* 7 teeth; ITC, 0. Scopula absent. Group of long hairs (not tufts) only below spines. Palp: fe p1d1.1.1.2r1; pa p1d1.1; ti p1r1. Pedal patellae with spine triad. Palp. Retroventral cymbium widely flared; VTA small rectanguloid; RTA low rectanguloid keel with small distal points; RTA small keel deeply invaginated forming two long similar lobes. DTP large trianguloid with retrolateral extension.

Female QM S107111. Carapace 7.20 long, 5.28 wide. Abdomen 6.00 long, 4.56 wide. Total, 13.20.

I: 5.84; 2.88; 5.52; 4.56; 2.16; 20.96. II: 5.84; 2.56; 5.04; 4.56; 2.24; 20.24. III: 6.00; 2.08; 4.72; 4.56; 2.24; 19.60. IV: 6.64; 2.48; 6.00; 6.32; 3.20; 24.64. Palp: 1.84; 1.20; 1.60; 2.24; 6.88.

Carapace with narrow brown margin, wide submarginal band; centrally darker with dark hair; white haired midline, submarginal white band extends across clypeus. Abdomen dorsally brown with pair of white lines anteriorly becoming paired white spots; venter pallid. Lateral of PLE entally and only partially overlapping a line of ca. 8 long bristles, similar line of 6–8 lateral of ALE and 5 in front of AME. *Eyes.* Group width/headwidth=0.60 through PLE, 0.46 through mid-eye group. OQ front, back, long: 33, 50, 30. MOQ front, back, long: 19, 25, 19. AME: ALE: PME: PLE, 7: 5: 10: 9. Caput shoulder weakly defined. AER with *ca.* 40% overlap; PER in two lines separated by half diameter of ALE. Chelicerae, 2p, 4r. STC with ca. 6–7 teeth; ITC, 0; palp 4. Scopula in lateral bands on metatarsi and tarsi I–IV. Palp: fe p1d1.1.1.2r1; pa p1d1r1; ti p2d1; ta p2r1. Pedal patellae with spine triad. Ventral spines on tibiae and metatarsi short, not overlapping. Epigyne. Broad triangular; with lateral lobes forming very obtuse

angle (i.e. almost transverse), septum absent. Internally, two slender ducts (Fig. 10g, i) loop widely spaced.

Remarks. L. Koch (1876) described and figured a male and female of *D. facetus* from Rockhampton, mid-eastern Queensland. However, Chrysanthus (1967), as well as Davies (1985), were unable to find the male (in ZMH, ZMB). Chrysanthus (1967) designated the adult female as lectotype and the juveniles are thus paralectotypes. However, RJR found a male and females, from the Godeffroy Collection in the Natural History Museum, London (BMNH), as is often the case with types from the Godeffroy Collection which were often sold (Baehr *et al.* 2017). He then illustrated a male (from New Guinea) which he considered was *D. facetus*. However, the male palp figured by Chrysanthus (figs 63, 67) showed a bilobed tibial apophysis (RTA) in retrolateral view with a short upper lobe and long lower, the reverse of the palp figured in Koch (1876, pl. 74, fig. 6b) and that of *Do. facetus* found widespread and figured here. As Chrysanthus noted, Koch's figure of the ventral face of the palp (1876) is unusually uninformative (cf. that of *D. flaminius*, pl. 75, fig. 4); however, it is clear that the distal tegular process is large (pl. 74, fig. 6a) and, in retrolateral view figured clearly (pl. 74, fig. 6b), two digitiform lobes are evident on the RTA, the upper clearly larger and slightly longer.

Davies (1985) followed Chrysanthus (1967), accepting his lectotype designation of the female in the face of the missing male which was part of the type series. However, RJR examined and drew a male, and two females in BMNH (1998) of *Do. facetus* labelled "types". Likewise, Catriona McPhee (pers. comm., Museum of Victoria, 2017) stated that a number of species with Museum Godeffroy numbers also occur in the collection of Museum of Victoria and are presumed types, in this case, paralectotypes.

Chrysanthus (1967) also figured and described a male of *D. chroesus* (figs 62, 66), previously known only from a female with an epigyne he thought very like that of *Do. facetus*. *Do. facetus* is a widespread species in Australia and the western Pacific and consistently shows the slightly longer upper lobe of the RTA consistent with Koch's figure and resembling Chrysanthus' male of *D. chroesus*. Thus, Chrysanthus (1967) mismatched the male of *Do. chroesus* to the female of *Do. facetus* and vice versa.

The epigyne of females of *Do. facetus* is unlike that of any described species.

Throughout its range in Queensland, the palp of *Do. facetus* shows little variation; however, the dorsal pattern on the abdomen is quite varied (Fig. 8a–d), seemingly depending on how well fed the spiders were. As the abdomen distends, the pattern becomes more distinct. They are the most elegantly coloured of the Australian *Dolomedes* species treated here and show more similarity in pattern to that of *Nilus*, eg. *N. curtus* O.P.-Cambridge, 1876 (see Dippenaar-Schoeman 2014, p. 125).

Dolomedes naja Berland (1938: 179, not examined) has a very similar palp to that of *Do. facetus* and may be a synonym.

Variation. Females from south-east Queensland (Fig. 10f) have a relatively longer overall epigyne than those from Cape York (*cf.* Musselbrook, Fig. 10h) and have no evident septum; the overall size of the ducts is slightly longer relatively in southeastern Queensland than Cape York and the female of *Do. facetus* figured by Chrysanthus (1967) resembles those from southeastern Queensland. Internally, the shape of the ducts in the epigyne are quite similar.

Distribution. Queensland, Western Australia, Northern Territory, Victoria, New South Wales and probably New Hebrides.

Dolomedes albicomus L. Koch, 1867
(Figs 5g, 7c, 11a, 12a–f. Map 1b)

Dolomedes albicomus L. Koch, 1867: 199; L. Koch, 1876: 875, pl. 75, fig. 3, 3a; Rainbow, 1911: 263; Davies, 1985: 102.

Material examined. Type. Queensland: holotype male, Brisbane, A. Dietrich, ZMH MGH 3503, examined.

Other material examined. Queensland: ma., Ayr, V. Salanitri, QM S28795; 1 fem., same data but 10 Jan 1974, QM S67793; fem., Deeral [17°10'S 145°50'E], 26 Mar 1950, J.G. Brooks, MV K13690; 1 ma., 1 fem., Toomba Homestead site, 19°58'S, 145°34'E, basalt ridge with *Brachychiton*, night collection, 16 Dec 2006, R.J. Raven, QM S79214; ma., Brisbane River,

Sherwood [27°31'S, 152°59'E], 1900–1907, SAMA NN135722; 2 fem., Brisbane River, [27°31'S, 152°59'E], Turner, SAMA NN13570, 71; 1 ma., Deception Bay, 27°09'S, 153°05'E, 22 Feb 1988, G. Larsen, QM S4534; 1 fem., Rochedale, Brisbane, 27°37'S, 153°09'E, scrub, 28 Nov 1973, G. Ingram, QM S67777; 1 fem., Home View, 28 May 2007, J. O'Flaherty, QM S75828; 1 ma., Wynnum N, Brisbane, 27°28'S, 153°03'E, 24 Jul 1990, QM S16455; 1 fem., Currumbin Ck, 11 Jan 1980, D. Seeton, QM S67791; 1 ma., Southbank, Brisbane, 27°28'S, 153°01'E, spider bite, 20 Mar 1993, Q.A.T.B., QM S22003. New South Wales: 1 ma., Stotts Is., Tweed R., 28°14'S, 153°31'E, sweeping, 19 Nov 1978, R.J. Raven, QM S96303; 1 fem., 3 ma., Pigabeen, Turners Dip, Tweed R., 28°10'S 153°28'E, 21–22 Nov 1978, R. Raven, H. Heatwole, G. Czechura, QM S107093.

Diagnosis. Males differ from those of *Do. instabilis* and *Do. mankorlod* sp. nov. in the median apophysis having a wide scoop and large sail-like keel retrolaterally on the distal portion (Fig. 12a). Females differ from those of *Do. instabilis* in the vulva having the CD and median lobe strongly overlapping (Fig. 12e).

Description. Male QM S28795. Carapace 6.25 long, 5.46 wide. Abdomen 5.75 long, 5.44 wide. Total, 12.

I: 7.81; 3.31; 7.75; 6.94; 4.44; 30.25. II: 7.75; 3.00; 6.88; 6.44; 3.88; 27.94. III: 6.88; 2.50; 5.94; 5.44; 3.00; 23.75. IV: 7.69; 2.69; 6.69; 7.69; 3.81; 28.56. Palp: 6.38; 2.38; 4.00; 1.94; 14.69.

Colour. Carapace red brown with yellow brown marginal band. Abdomen with distinct white flanks visible dorsally; venter pallid, without pattern. *Eyes*. Group width/headwidth= 0.52 through PLE, 0.57 through mid-eye group. OQ front, back, long: 71, 116, 78. MOQ front, back, long: 40, 55, 48. AME–AME, 7; AME–ALE, 5; PME–PME, 12; PME–PLE, 28. AME: ALE: PME: PLE, 15, 19, 24, 23. PLE posterior to caput shoulder. Chelicerae with 4 teeth on promargin, 3 on retromargin. STC with 7 long teeth; ITC with 1 long thin tooth. *Spines*. Legs I, II: fe p5d3r5; pa p1r1; ti p2d2r2v.2.2.2.2; me p2r2v2.2 + distal whorl of 4. Leg III, IV: as above but, pa p1d1 (apical)r1; ti p2d2r2v.2.2.2; me p2r2 v1.1.1.1 + distal whorl of 4. Palp: fe p1d1.1.2r2; pa 0; ti 0 (both palps). Leg tarsi slender, straight. Palp (Fig. 12a–c) very long. Tibia of male palp 1.87 times longer than cymbium. RTA retrolateral, a low ridge with cone on dorsal and ventral corners; VTA low, rounded, trianguloid. Cymbium elongate, apical cone short. Transverse part of tegulum slightly diagonal with deeply undulating distal edge; DTP slender, cucumiform, curved, not extending beyond MA. MA with long basal neck, deep flared apex with digitiform distal process on retrolateral edge.

Female QM S79214. Carapace 8.80 long, 7.44 wide. Abdomen 8.64 long, 5.44 wide. Total, 17.4.

I: 7.92; 4.08; 6.48; 5.36; 2.56; 26.40. II: 7.68; 3.84; 6.24; 5.36; 3.20; 26.32. III: 7.20; 3.44; 5.76; 5.20; 2.56; 24.16. IV: 8.56; 3.52; 7.60; 7.60; 3.44; 30.72. Palp: 3.60; 1.92; 2.16;2.56; 10.24.

Carapace and chelicerae redbrown with irregular narrow undulating pallid submarginal band; dark centrally. Abdomen dorsally dark with lighter upper flanks anteriorly, pallid ostiate region; venter pallid. *Eyes*. Group width/headwidth=0.60 through PLE, 0.48 through mid-eye group. OQ front, back, long: 21, 34, 20. MOQ front, back, long: 10, 15, 12. PLE set just behind midpoint of caput shoulder curve; AER have *ca*. 40% overlap; PER in slightly separated lines. Chelicerae: 2p, 4r. STC and palpal claw with *ca*. 5 teeth; ITC bare. Scopula light for distal prolateral edge of tibia I, absent on tibia II; strong on metatarsi and tarsi I, II. *Spines*. Palp: fe p1d1.1.1.2r1; pa p1, d1.1w; ti p2d1; ta p1r1v2.1. Patellar spines form triad but as with palp distal dorsal spine weak. Epigyne (Fig. 12d, e): *ca*. 1.2 times longer than wide, septum extend for distal 0.43 of length; median field with upturned corners; internally, ony median duct fully evident, other concealed.

Distribution. Eastern coastal Queensland and north-eastern New South Wales.

Variation. Through its long range from Toomba, just west of Townsville through to northern New South Wales, the relative length of the palpal tibia compared to the cymbium varies (see below) but in all other aspects the palps are similar and thus the spiders are considered conspecific. The patella to cymbium ratio of the palps of three males taken with a female from the Tweed River (QM S107093) were measured to check the reliability of the measure of the

length of the palpal tibia to cymbium; both palps were measured on each male.

Significantly, the length of the cymbium varied at most 10% and that was on the same animal. In contrast, the ratio of length of cymbium to tibia length varied from 1.62–1.91, with a difference of 1.68 and 1.91 on one male, with a mean of 1.73. However, on the most divergent male, the ratio of tibia to patella length was 1.40 on both sides. Over the three males, the ratio was 1.49–1.58, mean 1.49 with maximum specimen difference of only 3%.

Palps of the holotype male (from Brisbane) have a small trianguloid RTA (Fig.10f) whereas all males recently collected (past 40 years) from Ayr to Sydney have a second upper trianguloid dorsal spine on the RTA.

Remarks. Davies (1985: 103) noted L. Koch (1865) in the synonymy of *Dolomedes albicomus* but the only *Dolomedes* mentioned was *Do. australianus* L. Koch, 1865.

Dolomedes instabilis L. Koch, 1876
(Figs 11b, 13a–d, 14a–f. Map 1c)

Dolomedes instabilis L. Koch, 1876: 863, pl. 74, fig. 1; Rainbow, 1911: 263; Davies, 1985: 103. Type lost.

Dolomedes habilis Hogg, 1906: 589, fig. 89. New Synonymy.

Lycosa habilis: Rainbow, 1911: 268, incorrectly listed as *Lycosa habilis* Hogg; McKay, 1985: 78.

Dolomedes habilis: Hirst, 1988: 77, correction of type locality and restoration to *Dolomedes*, contra Rainbow, 1911.

Material examined. Types: New South Wales: holotype female of *Dolomedes instabilis* L. Koch, 1876, presumed lost, not found in ZMH, ZMB, NHMW, BMNH, MNHMP, Caigan [-31.6984°S, 149.2346°E], near Mudgee. South Australia: syntypes *Dolomedes habilis* Hogg 1906, 3 fem., Gilbert River, Riverton, South Australia, 34°10′S 138°45′E, SAMA.

Other Material Examined. Queensland: 1 ma., Boggomoss No. 3, via Taroom, 25°26′S, 150°01′E, 12 Nov 1996, P. Lawless, QM S37350; male, Boggomoss No. 3, via Taroom, 25°26′S, 150°01′E, 12 Nov 1997–Jan 1997, D. Cook. G. Monteith, QM S87988; male, Taroom District, Boggomoss No 21, 25°27′S, 150°02′E, foliage, night collection, 10 Nov 1996, P. Lawless, QM S37365; 1 fem., Taroom District, Boggomoss No 19, 25°25′S, 150°01′E, boggomoss, Lophostemon, night collection, 11 Nov 1996, P. Lawless, QM S37433; 1 fem., Taroom District, Mt Rose Station, BM13 (Hewitt), 25°28′S, 150°02′E, pitfall, 13 Sep 1996–11 Nov 1996, P. Lawless, QM S37469; 1 ma., Boggomoss No 32, Prices Ck via Taroom, 25°26′S4, 150°01′E, 14 Nov 1996, P. Lawless, QM S37389; 1 fem., Taroom district, Boggomoss No 21, 25°27′S, 150°03′E, open forest, pitfall, 9 Sep-10 Nov 1996, P. Lawless, QM S75637; 1 fem., Southwood near Moonie R, 24 Aug 1973, R.J. Raven, QM S67771; 1 ma., Taroom District, Boggomoss No 21, 25°27′S, 150°02′E, foliage, night collection, 10 Nov 1996, P. Lawless, QM S37365; 1 ma., Boggomoss No. 3, via Taroom, 25°26′S, 150°01′E, 12 Nov 1996–Jan 1997, D. Cook, G. Monteith, QM S87988; 1 fem., Kulgan Rd, Kalbar, 27°57′S, 152°37′E, 9 Jan 1994, L. Evans, QM S21633; 1 fem., Dalveen, 28°29′S, 151°58′E, house, Sep 1992–Feb 1993, G. Dutton, QM S20960; 1 fem., Biloela, 24°24′S, 150°31′E, 17 Jul 1992, D. Lack, QM S19603; 2 ma., 1 fem., Oakey, 27°26′S, 151°43′E, 12 Jan 1979, T. Adams, QM S67759; 1 fem., 1 pen. ma., 1 juv., Lake Broadwater via Dalby, 27°21′9″S, 151°5′31.5″E, Hand –under bark, 28 Jul 1984, QM S107071; 2 fem., Lake Broadwater via Dalby, 27°21′9″S, 151°5′31.5″E, 12 Feb 1984, QM S107073; 1 fem., Goondiwindi, 28°33′S, 150°19′E, QM S107074; 1 fem., Lake Broadwater, SW lake edge, near cottage, 23 Feb 1985, QM S107085; 1 fem., Lake Broadwater, overflow, 24 Nov 1984, QM S107086; 1 ma., Lake Broadwater, (overflow) via Dalby, 24 Nov 1984, QM S91006. South Australia: 1 ma., Adelaide, Botany Dept Adelaide University, Adelaide Plains, 34°56′S, 138°36′E, 25 Aug 1995, found while unpacking large mail bag from USA, SAMA NN13612; fem., Beltana, Flinders Ra., 30°49′S, 138°24′E, Nov 1941, V.H.M., SAMA NN8672; ma, 4 fem., juv., Brown Hill Creek, Mt Lofty Ra., 34°59′S, 138°37′E, 1 Feb 1935, H. Womersley, SAMA NN8657–62; ma., Bunyeroo Creek, ABC Range, Flinders Ra., 31°25′S, 138°34′E, 14–15 May 1990, D. Hirst, SAMA NN13588; fem., Ceres near Furner, Lower South-East, 37°19′S, 140°16′E, Feb 2001, R. Andre, SAMA NN13622; 4 ma., 1 fem., Coward Springs, Railway Bore, Lake Eyre Basin, 29°24′S, 136°48′50″E, 15–19 Apr 1996, D. Niejalke, SAMA NN13630, 13631, 13640–2; 1 ma., same data but, 25 Jul 1998, I. Gee, P., Coulls, SAMA NN8716; fem., Cox's Creek, Mylor, Mt Lofty Ra., 35°02′S, 138°45′E, 25 Apr 1936, H. Womersley, SAMA NN8656; fem., Dalhousie Springs, Lake Eyre Basin, 26°27′S, 135°31′E, 6 Sep 1980, G. Richardson-NPWS, SAMA NN13583; fem., Dog Lake Rd, SE of Langhorne Creek, Murray Mallee, 35°01′7″S, 013°92′E, Jun–Jul 1990, J. Eckert, SAMA NN13600; fem., Fred Springs, 16 km E, Lake Eyre Basin, 29°31′S, 137°25′E, 02 Oct 1978, P. Greenslade, SAMA NN13582; fem., Kapunda, Mt Lofty Ra., 34°20′S, 138°54′E, 7 Jun 1975, J. Mcmara, SAMA NN8671; fem., Keilira Station, 13 km N, Upper South-East, 36°37′S, 140°10′E, 22 Mar 1992, D. Hirst, on flat under damp rocks, SAMA NN13620; fem., Langhorne Creek, Murray Mallee, 35°01′7″S, 013°92′E, Jan 1988, C.L. Wilton, SAMA NN13604; 2 fem., Leigh Creek, Flinders Ra., 30°35′S, 138°24′E, W.B. Greenwood, SAMA NN13585, 86; fem., Mambray Creek, Mt Remarkable NP, Flinders Range, 32°49′S, 137°58′E, 01 May 1983, G. Coombe,

NPWS, SAMA NN13584; fem., juv. Melrose, Flinders Ra., 32°49′S, 138°11′E, 17 Apr 1987, D. Hirst, camping ground, creek, SAMA NN13587; fem., Milang, Mt Lofty Ra., 35°24′S, 138°58′E, Jan 1999, T. Sim, SAMA NN13613; ma., Monteith, Murray Mallee, 35°10′S, 139°19′E, 25 Feb 1984, B. Guerin, beside dam, SAMA NN13602; 2 ma., Morris Creek Bore, Lake Eyre Basin, 29°25′40″S, 137°34′E, 29 Mar 1996, D. Niejalke, SAMA NN13634, 35; ma., pen fem., same data but 24 Jan 1996, D. Niejalke, ex Cyperus, SAMA NN13639; fem., Old Finniss Spring, Lake Eyre Basin, 29°45′S, 137°31′E, 17 Oct 1995, D. Niejalke, SAMA NN13629; ma., pen fem., Old Finniss Spring, Lake Eyre Basin, 29°45′S, 137°31′E, 1995, D. Niejalke, SAMA NN13638; 1 fem., 1 penult. fem., Onkaparinga River, Mt Lofty Ra., 35°08′S, 138°37′E, 1922, R.H. Pulleine, SAMA NN8667; 1 fem., Outside Spring, Lake Eyre Basin, 28°16′S, 136°13′E, 22 Aug 1996, D. Niejalke, SAMA NN13636; fem., Outside Spring, Lake Eyre Basin, 28°16′S, 136°13′E, 22 Aug 1996, D. Niejalke, SAMA NN13637; fem., Salt Creek, near Ungarra, near Tumby Bay, Eyre Peninsula, 34°01′S, 136°02′E, 23 Mar 1980, W. Zeidler, SAMA NN13593; fem., Sleaford Bay, Eyre Peninsula, 34°53′S, 135°43′E, 4 Jan 1964, J. Casanova, SAMA NN13596; fem., Sleaford Mere, Eyre Peninsula, 34°50′S, 135°44′E, 27 Jan 1971, J. Casanova, SAMA NN13597; fem., pen fem., Sleaford Mere, SW of Port Lincoln, Eyre Peninsula, 34°50′S, 135°44′E, 27 Mar 1987, D. Hirst, Lee, D C, SAMA NN13592; pen. fem., St Peters, Adelaide Plains, 34°54′S, 138°37′E, Dec 1957, SAMA NN8670; ma., 'The Fen' mound spring, near Hermit Hill, Lake Eyre Basin, 29°34′10″S, 137°25′30″E, 24–29 Jan 1996, D. Niejalke, pitfall, SAMA NN13643; fem., egg mass Tolderol Game Reserve, Lake Alexandrina District, 35°02′1″S, 513°99′3″E, 3 Jan 2002, Eckert, J, under water couch, SAMA NN29308; 1 ma., Windsor Gardens, Adelaide Plains, 34°52′S, 138°39′E, 24 Oct 1993, D. Hirst, SAMA NN13611; 1 ma., 1 juv., Waterfall Gully, 32°45′S 137°42′E, 3 Oct 1978, P. Walker, AM KS32117. New South Wales: 1 fem., Cooks Gap near Mudgee, 32°24′S 149°42′E, 2 Feb 1981, H. Neugebauer, AM KS6773;1 fem., Gurley Ck at "Carrington", 29°39′25″S 149°36′59″E, 29 Mar 2010, D. Mawer, AM KS112416; 1 fem., Eglinton, 33°23′S 149°32′E, 19 Jan 1971, B. Eltham, AM KS56854; 1 fem., Mt Riverview near Blaxland, 33°44′S 150°37′E, 18 Jan 1981, Fisher, AM KS6607; 1 fem., Burrawye Ck at Burrawye Keotong Ck Rd, 36°04′02″S 147°33′45″E, 11 Nov 2009, J. Miller, AM KS110789; 1 fem., Chipping-Nelson area, 33°39′S 150°55′E, 22 Jan 1979, M. Julian, AM KS2737; 1 fem., (no locality name), 37°15′S 145°00′E, R. Helms, AM KS21616; 1 fem., Broken Hill, 31°57′32″S 141°27′49″E, 1 Dec 1973, R. Todd, AM KS105744; 1 fem., Belmore, 3 Feb 1930, Mrs Campbell, AM K61138; 1 fem., Moorbank, nr Liverpool, March 1950, J. Ashtbury, AM KS; 1 ma., Merrowrie Creek crossing, Lachlan Wetlands, 33°25′39″S 145°18′25″E, 6 Oct 2013, B. Haine, AM KS123220; 1 ma., Murray River at Cobram, 35°54′28″S 145°39′36″E, 30 Oct 2011, D. Mawer, AM KS117695; 1 ma., 6.5 km along access track to Narran Lake Reserve, 29°42′52″S 147°25′19″E, 24 Nov–14 Dec 1999, Pitfall, F. Christie, P. Flemons, M.G. Elliott, AM KS77053; 1 ma., Nebea Creek on Carrana, 30°45′05″S 148°20′37″E, 26 Mar 2010, G. Theischinger, AM KS113964; 1 ma., Upper Hunter River, Cliffords Quarry at Aberdeen, 32°08′09″S 150°55′36″E, 17 Jan–1 Feb 2006, Pitfall, J. Gollan, AM KS98316; 3 ma., ca. 100 m along access rd to Warrambungles NP, 31°25′09″S 148°31′19″E, 21 Nov–11 Dec 1999, pitfall, L. Wilkie, R. Harris, T.M. Moulds, AM KS71469–71; 1 ma., Gloucester, Sieve Cave (gloworm), 32°03′37″S 152°05′01″E, 7 Mar 1995, S. Eberhard, AM KS51020; 1 ma., Berida Station 22 km W of Gilgandra, 31°39′S 148°27′E, 27 Mar 1982, W. Bell, AM KS8857; 1 ma., 1 fem., 1 juv., Glen Osmond Quarry, A. Zietz, AM KS57501; 2 ma., Murray Valley National Park, 35°48′S 145°10′54″E, 10–14 Feb 2015, pitfall, I. Oliver et al., AM KS124768, 125157; 1 ma., Bonnie Doon Golf Club, "Armcliffe", Jan 3, 1933, J. Logan, AM. Northern Territory: 1 fem., Reedy Hole [23°40′S 132°40′E], Horn Expedition, 1894/95, juvenile fem., Saxon Ck, 10 km N Frankfort [41°16′S 146°42′E], 19 Nov 1972, A. Neboiss, MV K–13676; ma., fem., Finke River Gorge, S of Hermannsburg, Central Australia, 23°55′S, 132°43′E, 16 May 1976, R.C. Kowanko, SAMA NN13652, 53; 1 ma., Hermannsburg, Central Australia (23°56′S, 132°46′E), H.A. Heinrich, SAMA NN13648. Victoria: 1 ma., Hurstbridge, Melbourne, 2 Apr 1990, P. Vaughn, MV K; ma., Royal Botanic Gardens, in sink in building, 37°49′50.50″S, 144°58′38.09″E, 25 Jan 2017, V. Stajsic & B. Gunn, MV K–13619; fem., "Orchards", 27 Mar 1991, MV K–13677; ma., 1k N of Galah 517667 [35°00′S 142°10′E], 29 Oct 1974, MV K–13678; ma., Melbourne western region invertebrate survey, Point Cook [37°50′S 144°40′E], Red gum, 23–30 Jan 1992, pitfall, MV K–13680. Victoria Remnant Woodland Study: fem., site 101G, Booths Rd, 0.2 km S of Murray Valley Highway 36°08′S 145°11′E 17–22 Jan 1994, pitfall, G. Milledge, MV K–13679; ma., site 131, McInnes Rd, 35°55′S 144°22′E Jan 1993, pitfall, A. Bennett, MV K–13681; ma, (palp tibia, cymbium absent), site 4, Reef Hills Rd, 36°35′S 145°58′S, Jan 1993, pitfall, A. Bennett, MV K–13682; fem., site 158, Mt Hope Ck, Jungaburra Homestead, 1k SSE, 36°05′S 144°19′E, Jan 1993, pitfall, A. Bennett, MV K–13683; fem., site 164, Cant Rd, 36°16′S 144°23′E, Jan 1993, pitfall, A. Bennett, MV K–13684; ma., site 43, Winton–Lurg Rd, 36°33′S 146°06′E, Jan 1993, pitfall, A. Bennett, MV K–13685; ma., site 170, Longwood–Pranjip Rd, 36°45′S 145°24′E, Jan 1993, pitfall, A. Bennett, MV K–13686; 1 ma., 1 fem., site 114, McInnes Rd, 35°54′S 144°22′E Jan 1993, pitfall, A. Bennett, MV K–13687; 1 fem., "Victoria", SAMA NN13659. Papua New Guinea: 1 ma., 1 juv., Kairiru Island, 3°20′S 143°33′E, 11 Feb 1976, O.W. Borrell, AM KS7961; 1 fem., Kairiru Island, 3°20′S 143°33′E, 10 Oct 1979, O.W. Borrell, AM KS8039; ma., Kairiru Island near lake, 3°20′S 143°33′E, 23 May 1976, O.W. Borrell, AM KS8016.

Diagnosis. Males belong to the long-palped *Do. albicomus* group but differ from those of *Do. albicomus* in the median apophysis with small trianguloid process retrolaterally on basal portion (Fig. 13a), and from that of *Do. mankorlod* sp. nov., in the sausage-shaped DTP, varying little in diameter across its length. Females and males are unusual in Australian *Dolomedes* in having a black field with four convergent longitudinal pallid stripes ventrally. Females of *Do. instabilis* differ from those of *Do. albicomus* in that the ectal (insemination) loop lies is almost entirely overlapping (i.e. hidden when viewed from below) by the median loop, and from those of *Do. vicque* sp. nov., in that the lateral ridges of the epigyne narrow quickly at the line of the median field (Fig. 14a, c, e) rather than curving smoothy (Fig. 16g).

Description. Male QM S37350. Carapace 6.38 long, 5.63 wide. Abdomen 4.50 long, 3.25 wide. Total, 11.2.

I: 7.31; 3.38; 6.88; 6.38; 4.38; 28.31. II: 7.50; 3.13; 6.50; 5.94; 3.69; 26.75. III: 6.69; 2.63; 5.69; 5.69; 3.13; 23.81. IV: 8.00; 2.88; 7.00; 7.81; 4.13; 29.81. Palp: 4.44; 1.69; 2.38; 2.19; 10.69.

Colour. Carapace: broad undulating band of white hair narrows beside eyes, widest at caput edge. Ventral abdomen with dark trapezoidal pattern with pairs of submarginal pallid lines and medial lines. *Eyes.* Group width/headwidth=0.56 through PLE, 0.46 through mid-eye group. OQ front, back, long: 70, 117, 65. MOQ front, back, long: 41, 57, 42. AME–AME, 12; AME–ALE, 5; PME–PME, 17; PME–PLE, 22. AME: ALE: PME: PLE, 18:12:20:20. PLE in line of caput shoulder curve; PER with 50% overlap. Chelicerae with 3 teeth on promargin, 4 on retromargin. STC on I with 4 long teeth; ITC 0. *Spines.* Legs I, II: fe p5d4r5; pa p1r1; ti p2d2r2v.2.2.2.2; me p2r2v2.2 + distal whorl of 4. Leg III, IV: as above but, pa p1d1 (apical)r1; ti p2d2r2v.2.2.2; me p2r2 v2.2.2 + distal whorl of 4. Palp: fe p1d1.1.1.2r1; pa p1 apical 1; ti 0. Tarsi straight. Palp (Fig. 13a–c): all palpal segments elongate; tibia of male palp 1.27 times longer than cymbium; RTA retrolateral with two small cones on edge of low keel; ventral tibial apophysis small, rounded with small apical invagination. Cymbium with small retrobasal flange and wide margin to bulb. Transverse part of tegulum slighly diagonal with low distal undulation; DTP curving, similar width, almost cylindrical varying little over its length extending just past MA. MA anvil-shaped with short neck and trianguloid vane retrobasally.

Female QM S37433. Carapace 9.69 long, 8.75 wide. Abdomen 11.56 long, 9.06 wide. Total, 21.25.

I: 8.31; 4.69; 7.56; 6.50; 4.31; 31.38. II: 8.44; 4.56; 7.38; 6.38; 3.56; 30.31. III: 8.06; 3.94; 6.75; 6.63; 3.19; 28.56. IV: 9.81; 4.31; 6.63; 8.75; 4.13; 33.63. Palp: 3.94; 1.94; 3.19; 3.13; 12.19.

Colour. Carapace: median narrow band of white hairs widening just anterior to fovea, brown with irregular pallid "islands" submarginally; long hairs overhand PLE and in MOQ. Abdomen, dorsally medially with anterior ostiate mark, irregular mottling elsewhere; ventrally with median dark trapezoidal field bounded by pallid lines and with pair of median pallid lines. *Eyes.* Group width/headwidth=0.68 through PLE, 0.60 through mid-eye group. OQ front, back, long: 32, 40, 24. MOQ front, back, long: 16, 19, 14. AME–AME, 20; AME–ALE, 12; PME–PME, 24; PME–PLE, 33. AME: ALE: PME: PLE, 25, 21, 28, 28. Chelicerae with 3 teeth on promargin, 4 on retromargin. *Claws.* STC on I with 7 long teeth; ITC 0, none on palpal claw. Retroventral scopula fringes on pedal metatarsi and tarsi and strong ventral bristles on tarsi. *Spines.* Legs I, II: fe p5d3r5; pa p1r1; ti p2d2r2v.2.2.2.2; me p2r2v2.2 + distal whorl of 4. Leg III, IV: as above but, pa p1d1 (apical)r1; ti p2d2r2v.2.2.2; me p2r2 v1.1.1.1 + distal whorl of 4. Palp: fe p1d1.1.1.2r1; pa p1d1+apical; ti p2d2. Epigyne (Fig. 14a–f). Overall shape 1.11 times longer than wide. Lateral lobes uniformly curving, converging posteriorly. Median field occupies ca. 0.53 of overall length. Overall internal ducts broadly N-shaped; CD slightly shorter or longer than median fold (Fig. 14b, d, f) and not juxtaposed, inner fold slightly shorter than median fold.

Distribution. Southern Queensland, western New South Wales, Victoria, Australian Capital Territory, South Australia and Papua New Guinea. Hirst (1988) amended the type locality

of *Do. habilis* to Gilbert River, Riverton, South Australia, 34°10′S 138°45′E. None have yet been found in Tasmania.

Sexual dimorphism. Males and females taken together (QM S67759) show no correspondence of the scopula on metatarsi I, II which is absent in males and present in females; some females also show no ventral abdominal pattern. One syntype of *Do. habilis* has 4 stripes on ventral abdomen (Hogg, 1906). Equally, in a female (QM S37433), the venter has four pallid lines converging at spinnerets breaking up a dark field (as in Fig. 36c, d) and a scopula on metatarsus and tarsus I also present in the described male.

Remarks. The figure of the epigyne of the lost holotype (L. Koch, 1876, pl. 74, fig. 1) of *D. instabilis* presents little information. The epigyne is 1.33 times longer than wide and the septal area is 0.64 of the overall length. Several species, all with a similar epigyne, have consistently different spermathecae. Thus, specimens previously identified from females as *Do. instabilis* based upon the similarity of the epigyne need to be dissected.

The association of the male with the female of *Dolomedes instabilis* was made using the South Australian Museum collection of pisaurids from the Adelaide region, a well represented area in the collection. Apart from *Ornodolomedes southcotti* sp. nov., the pisaurid fauna is three species of *Dolomedes*. One is *Do. facetus* which are well known. The most common large species is *Dolomedes instabilis*; a third undescribed species also occurs there and is quite different.

No further material of *D. instabilis* has been described in the scientific literature (WSC, 2017). However, because many species of *Dolomedes* have little difference in abdominal pattern and otherwise somatically appear quite similar, many images in popular literature and the Atlas of Living Australia (www.ala.org.au) are mis-identified as *D. instabilis*. In general, with the exception of *Do. facetus*, identification of *Dolomedes* species from photographs, especially of females but also of males is not generally possible.

The only possible reason for maintaining the New Caledonian *Do. lafoensis* Berland, 1924 is if the retrolateral flange on the median apophysis (not shown by Berland, 1924) is absent or different to that in *Do. instabilis*. The flange is very difficult to see unless the light angle is altered to different positions; it was not shown in L. Koch's illustration of the type but is clearly present.

Dolomedes vicque sp. nov.

(Figs 1b, 15a–d, 16a–h, 17c. Map 1d)

Etymology. The species epithet is an arbitary combination of letters of the two states at the edge of its known range, Victoria and Queensland.

Material examined. Queensland: holotype male, 1 fem., Teviot Brook, Boonah, 27°55′S, 152°33′E, rainforest, 3 Oct 1973, V.E. Davies, QM S188; 1 fem., same data but 21 Oct 1973, QM S91002. Victoria: Avon R near Valencia Ck, 37°48′S, 146°57′E, gravel bank in stream bed, V. Framenau: 1 ma., 6 Oct 1997, QM S53977; 1 fem., near Wombat Xing, 10 Apr 1997, QM S63911; 1 fem., 12 Feb 1997, QM S53976; 1 ma., 7 May 1997, QM S51050; fem., 12 Feb 1997, WAM T51482; 1 ma., 1 fem., 1 juv., 16 Oct 1996, WAM T51480; 1 fem., 22 Oct–8 Nov 1996, wet pitfall, WAM T51479; 1 fem., 12 Mar 1997, WAM T51481; 1 fem., Lerderderg River, 37°36′S, 144°24′E, 6 Jul 1996, V. Framenau, hand collection, riparian gravel bank, WAM T51478; 1 ma., Howqua River, 37°12′S, 146°28′E, 26 Jan 1999, V. Framenau, hand collection, riparian gravel bank, WAM T51483. New South Wales: 1 ma., Minnamurra Falls, 18 Oct 1964, R. Mascord, AM KS124037; 1 fem., Oxley Wild Rivers NP, Macleay River, East of Gara River junction, 30°39′50″N, 151°51′39″E, 367 m, 9 Nov 2015, H.M. Smith, AM KS124478; 1 fem., Fig-Tree Cave, Wombeyan Caves, 34°18′41″S 149°57′55″E, 15 Oct 1952, P.M. Pinnock, AM KS115614; 1 fem., Naringal 17 km E of, 38°25′S 142°48′E, 27 Aug 1978, H. Parnaby, AM KS44484.

Diagnosis (Fig. 16a–f)**.** Males differ from those of other species with a short palpal tibia by the slender tapering RTA (Fig. 16e) with small lateral lobes along its length. Females are similar to those of *Do. briangreenei* sp. nov., in the small pair of cones on the median epigynal field but differ in the N-shaped (two parallel lobes joined dorsally by a diagonal duct) spermathecal line (Fig. 16h).

Tibia about as long as cymbium, distal incrassate most noticeable in ventral view (Fig. 16a); ventral tibial apophysis lobular, slightly

diagonal, directed retrolaterally, irregular tip; RTA bifid, upper lobe long, slender, lower lobe rounded, both on offset base, Cymbium with basodorsal mound (Fig. 16b); retrobasal process bipartite, basal part small, digitiform, retrobasal part with complex twisted groove (Fig. 16a, b); cymbial cone short, rounded, lacking spines; retrobasal cymbium with broad flange. Tegulum of dissimilar width for its length, distal tegular lobe broad, basal transverse portion narrow with anterior lobe on retrolateral corner, median apophysis basally narrow widening quickly to flared V-shape, in cross-section (as in Fig. 13c). Short portion of embolus evident distally with conductor lying retrolaterally.

Description. Holotype Male QM S188. Carapace 7.44 long, 6.40 wide. Abdomen 6.48 long, 3.60 wide. Total, 13.9.

I: 7.36; 3.44; 6.40; 6.56; 4.32; 28.08. II: 7.60; 3.60; 6.40; 6.64; 3.20; 27.44. III: 6.48; 2.64; 5.60; 5.20; 2.96; 22.88. IV: 7.60; 2.88; 6.80; 8.08; 3.92; 29.28. Palp: 4.80; 1.84; 2.00; 2.56; 11.20.

Colour. Carapace red-brown with dark marginal band and submarginal band of white hair. Abdomen faded, ostiate area pallid, ventrally dark. Carapace with fringe of strong bristles arising behind and overhanging PLE, strong lateral fringe in diagonal line over PME. *Eyes.* Group width/headwidth=0.69 through PLE, 0.55 through mid-eye group. PLE at mid-shoulder. OQ front, back, long: 35, 55, 32. MOQ front, back, long: 18, 25, 18. AME: ALE: PME: PLE, 7:6:10:11. Back eye row is two close lines separated by 0.2 of PME diameter; from above, AER 30–40% overlap. Chelicerae with 2 large teeth plus one small tooth on promargin, 4 on retromargin. STC with 7 teeth; ITC bare. *Spines.* Apical patellar spines weak on I, II. Strong but short, non-overlapping on tibiae and metatarsi I, II. Palp: fe p1d1.1.1.2r1; pa p1d1.1; ti p1. Pedal patellae spines form triad. Scopula absent. *Palp* (Fig. 16a, b). Tibia of male palp short, cymbium 1.3 times longer than tibia; retrobasal cymbium with wide flare with unequally divided retroventral plate. RTA long trianguloid with 2–3 processes. Tegulum transverse. DTP narrowly triangular. Median apophysis long slender, apical scoop small.

Female QM S91002. Carapace 8.08 long, 6.40 wide. Abdomen 9.92 long, 7.20 wide. Total, 18.0.

I: 6.96; 3.12; 5.68; 5.44; 3.12; 24.32. II: 7.28; 3.28; 5.60; 6.32; 3.04; 25.52. III: 6.40; 2.96; 5.36; 5.20; 2.56; 22.48. IV: 7.52; 3.20; 6.96; 7.84; 3.20; 28.72. Palp: 3.20; 1.52; 2.08; 2.48; 9.28.

Colour. Carapace faded, yellowish with broad bark margins, lighter submarginal band widest at coxae I with broad white midline for anterior half of caput. Abdomen faded yellow brown, no ventral pattern but female from Avon River (Victoria, WAM T51481) has ventral pattern, less evident on second sympatric female. *Eyes.* Group width/headwidth=0.61 through PLE, 0.48 through mid-eye group. OQ front, back, long: 37, 58, 32. MOQ front, back, long: 17, 27, 22. AME: ALE: PME: PLE, 7:6:12:12. PER two lines separated only by 0.16 of PME; from above, AER with 50% overlap. Chelicerae with 2 large and one small tooth on promargin, 4 on retromargin. STC with 9 long teeth; ITC bare. Scopula in lateral fringes on metatarsi and tarsi I–III, none on tibia I. *Spines.* Pedal patellae with triad but apical spines on I–III weak. Paired ventral spines on tibiae and metatarsi I, II not overlapping. Palp: fe p1d1.1.1.2r1; pa p1d1.1; ti p2d1r1; ta p2r2. Epigyne (Fig. 16g, h). Overall, cordate with long median field with pair of low cones on lateral corners; internally short N-shaped ducts.

Distribution. Eastern Australia from eastern Victoria, through coastal New South Wales near Kiama and into south-eastern Queensland.

Dolomedes briangreenei sp. nov.

(Figs 17a, b, 18a–d, 19a–h, 20a–d. Map 1e)

Etymology. The species epithet is in honour of Professor Brian Greene, world renowned physicist and co-founder of the World Science Festival to celebrate Professor Greene's contributions to science. Professor Greene is one of the world's leading experts in exploring and explaining the effects of gravitational waves in the universe and the connection was due to the way pisaurids hunt their prey on water using waves and associated vibrations. Australian pisaurids are known to eat fish, tadpoles and frogs

and thus highly likely to also feed on small Cane Toads, *Rhinella marina* (Linnaeus, 1758).

Material Examined. Queensland: holotype male, Kroombit Tops (Three Moon Ck), 45 km SSW Calliope, 24°25′S, 151°02′E, rainforest, 9–19 Dec 1983, V. Davies, J. Gallon, QM S63910; 2 ma., 1 fem, same data as holotype, QM S63910; 1 ma., 1 fem., Mudgeeraba, 28°05′S, 153°22′E, along creek, 22 Jan 1986, R. Raven, J. Gallon, QM S67767; 2 fem., Numinbah, 28°11′S, 153°15′E, in caves, 18 Dec 1973, G. May, QM S67783; 2 fem., McLeod Mountainn near Windsor Tableland, camp site, 17–23 Dec 1980, ANZSES expedition, QM S67775; 1 ma., 1 fem., Mt Nebo, 27°23′S, 152°47′E, 3 Dec 1974, D. Smyth, G. Ingram, QM S193; 1 fem., Booloumba Ck, Conondale Ra., 26°39′S, 152°39′E, 1974, R.J. Raven, QM S67778; 1 fem., Upper East Funnel Ck, 21°34′S, 149°12′E, 15–16 Nov 1992, G. Monteith, G. Thompson, D. Cook, H. Janetzki, QM S49454; 1 fem., Boondall Wetlands (BCC1), 27°20′S, 153°04′E, *Melaleuca* wetland, pitfall, 2 Sep–2 Oct 2003, QM party, QM S62826; 1 fem., Proserpine, Deadman Creek, site XY17, 20°30′S, 148°33′E, open forest, night collection, 17 Mar 2008, R.J. Raven, QM S85988; 1 fem., Mt Elliot NP, North Ck, 19°29′S, 146°58′E, 25–27 Mar 1991, G. Monteith, D. Cook, QM S17934; 1 fem., Paluma NP at Paluma, 19°00′S, 146°12′E, hand collection, 25 Oct 1991, G. Monteith H.Janetzki, QM S59048; 1 ma., 1 fem., Home Rule, Wallaby Ck, 15°44′S, 145°18′E, rainforest, 19 Nov 1974, J. Covacevich, D. Joffe, V.E. Davies, QM S191; 1 fem., Rathdowney nr, 28°13′S, 152°52′E, Dec 1975, C. Corben, QM S67764; 1 fem., Mt Spurgeon, Sandy Ck, 16°28′S, 145°12′E, 22 Nov 1997, G. Monteith, QM S43344; 2 fem., Kilcoy Ck, E branch, 26°42′S, 152°34′E, 14 Feb 1979, K.R. McDonald, QM S67788; 1 ma., Mt Abbot, 20°06′S, 147°45′E, C, 9–12 Apr 1997, G. Monteith, H. Janetzki, D. Cook, QM S50714; 2 fem., Cameron Ck, upper, 21°35′S, 149°11′E, rainforest, hand collection, 1–2 Oct 1999, G. Monteith, D. Cook, C. Burwell, S. Evans, QM S19811;1 ma., 2 fem., Bunya Mtns NP, Dandabah, 26°54′S, 151°37′E, 1–7 Mar 1976, Queensland Museum Party, QM S67787. New South Wales: 1 fem., Bruxner Park, 30°14′S, 153°06′E, rainforest, 12 Nov 1980, R.J. Raven, QM S67790; 1 fem., Mt Warning, 28°25′S, 153°17′E, night collection, 3 Dec 1974, R.J. Raven, QM S677431 fem., Wallaby Ck, Tooloom, 28°37′S 152°25′E, 4 Dec 1962, Naval Exped., AM KS68012; 1 fem., Oxley Wild Rivers National Park, East Kunderang Track, 30°48′25″S 152°07′09″E, 12 Nov 2015, C. Nzama, AM KS124524; 1 fem., Sharpers Ck, Boundary Rd, N of Sharpers Rd, Nerong SF, 32°31′37″S 152°07′E, 30 m, 4 Feb–9 Apr 1993, pitfall, G.A. Cassis, M.R. Gray, AM KS42180; 2 ma., Washpool State Forest, Coombadjah Ck, 0.6 km from Moongem Rd, 29°16′S 152°22′E, 13 Feb 1982, C. Horseman, AM KS9236, 9348; 1 ma., 1 fem., Dome Mountain, Richmond Range, Yabbra SF, 28°28′S 152°43′E, 900 m, 11 Dec 1989, Pitfall, Smith, Hines, Pugh & Webber, AM KS51281; 1 ma., 1 fem., 1 juv., Bellangary State Forest Wilson River Flora Reserve, 31°18′S 152°29′E, 7 Dec 1981, M. Gray *et al.*, AM KS9688.

Diagnosis. Among species with males that have the palpal tibia clearly shorter than cymbium, they are unusual in the long flared RTA and differ from that of *D. flaminius* in that the DTP is slender and curved not short and triangular and straight, and from those of *Do. vicque* in the broad flared RTA. Females are unusual in the soft curved horn-shaped lobes on the lateral epigynal field (Figs 18c, 19a, 20c) and may also have a conical medial process (Figs 18c, 20c).

Description. Holotype male QM S63910. Carapace 6.48 long, 5.60 wide. Abdomen 6.00 long, 3.60 wide. Total, 12.48.

I: 7.83; 3.33; 7.17; 6.67; 3.83; 28.83. II: 8.00; 3.33; 7.00; 6.83; 3.50; 28.67. III: 7.50; 3.00; 6.00; 3.83; 2.67; 23.00. IV: 8.33; 3.00; 7.17; 8.83; 3.67; 31.00. Palp: 4.17; 1.67; 1.83; 2.83; 10.50.

Carapace with lateral band widest anterior to mid-fovea, narrow for caput; no medial pallid line. Abdomen faded, no shoulder band or upper pallid line, no ventral pattern. *Eyes.* Group width/headwidth=0.64 through PLE, 0.33 through mid-eye group. OQ front, back, long: 29, 48, 27. MOQ front, back, long: 15, 23, 16. PLE through mid-should curve; AER almost in 2 rows; PER two just separated lines. STC with *ca.* 5 teeth; ITC bare. Scopula absent, strong bristles on ventral tarsi IV; no modifications of femur IV. *Spines.* Palp: fe p1d1.1.1.2r1; pa 0; ti p1d1; ta 0. Palp. palpal tibia clearly shorter than cymbium; DTP long slender digitiform, with basal bulge and mid-distal narrowing, directed almost parallel to median apophysis only lying dorsad and apically; tegulum also diagonally; retroventral cymbial corner narrowly and gradually flared; RTA distal, long, flared with various smaller lobes usually one dorsally, rarely two.

Female QM S63910. Carapace 10.08 long, 8.24 wide. Abdomen 10.32 long, 6.00 wide. Total, 20.40.

I: 9.67; 4.83; 9.00; 8.33; 4.17; 36.00. II: 10.17; 5.00; 9.00; 8.33; 4.00; 36.50. III: 9.17; 4.50; 7.00; 7.50; 3.50; 31.67. IV: 10.50: 4.67; 9.00; 10.67; 4.50; 39.33. Palp: 4.17; 2.17; 2.67; 3.50; 12.50.

Carapace red-brown with broad lateral bands, no pallid medial line, lateral band widest anterior to mid-fovea, narrow for caput; no medial pallid line. Abdomen faded, no shoulder band or upper pallid line, no ventral pattern. *Eyes.* Group width/headwidth=0.65 through PLE, 0.31 through mid-eye group. OQ front, back, long: 50, 75, 43. MOQ front, back, long: 25, 34, 25. PLE through mid-shoulder curve; AER rows contiguous; PER two separated lines. STC with *ca.* 5 teeth; ITC bare. Scopula absent. *Spines.* Palp: fe p1d1.1.1.2r1; pa p1; ti p2d1; ta p1r1v1.2. Epigyne (Fig. 18c, d) with roughly V-shaped median field with central cone and pair of ridges laterally; septum in distal third; broad CD folding twice with first lobe broad and second, if actually a lobe, much thinner.

Distribution and Habitat. Rainforest and open forest streams from northern New South Wales to north-east Queensland.

Remarks. Material from well north (1000 km) of the type locality (Kroombit Tops) shows slight differences in the RTA shape (Fig. 20b) and the broad spermathecal duct is longitudinal not diagonal as in the southern specimens. However, some females have little or no medial cone (Fig. 19c) and others have well developed lateral hooks (Fig. 19a), all of which are soft tissue, and internally they are little different. The difference in the RTA of northern specimens (Fig. 20b) also lies within the variability of those in the south (Fig. 19e–h). Thus, looking at the variability accepted by Vink & Dupérré (2010) in concordance with molecular data, this variation is considered intraspecific.

Dolomedes venmani sp. nov.
(Figs 21a, b, 22a–d. Map 1f)

Etymology. The species epithet is in honour of Jack Venman (13 August 1911–29 December 1994), a farmer who, wanting to preserve the great biodiversity in the area, "sold his 255 acres to the Queensland Government in 1971 for $1."

Material examined. Type. Queensland: holotype male, Mt Cotton, Venman's Reserve, 27°37'S, 153°13'E, 29 Sep 1973, P. Belfield, QM S67741.

Other Material examined. Queensland: 1 ma, same data as holotype, QM S108240; 1 ma., 2 fem., 2 juv., Eagers Swamp, Moreton Island, pitfall, Environmental Impact Study (W. Houston), 24 Sep 1982, QM S107110; 1 fem., Teewah Ck, Cooloola, 25°56'S, 153°02'E, 13 Jul 1973, R.J. Raven, QM S67786; 1 fem., Booloumba Ck, Conondale Ra., 26°39'S, 152°39'E, 1974, R.J. Raven, QM S67779; 1 ma., Eprapah Ck, Redlands, Aug 1995, C. Moriaty, QM S33665; 2 fem., Cedar Galleries, dam, Calliope, 23°59'S, 151°10'E, 27 Feb–1 Mar 2017, R. Raven, QM S108245. New South Wales: 1 fem., Pigabeen, Turners Dip, Tweed R., 28°10'S 153°28'E, 22 Nov 1978, R. Raven, H. Heatwole, G. Czechura, QM S107091; 1 fem., Stotts Island, Tweed River, 28°14'S, 153°31'E, sweeping, 19 Nov 1978, R.J. Raven, QM S67769; 1 fem., Sharpers Ck, Boundary Rd, N of Sharpers Rd. Nerong SF, 32°31'37"S 152°07'E, 30 m, 4 Feb–9 Apr 1993, Pitfall, G.A. Cassis, M.R. Gray, AM KS42180; 1 fem., Frenchs Forest, 33°45'S 151°14'E, 20 Aug 1968, I. Edmunds, AM KS767; 1 ma., Lake Innes, 31°29'S 152°52'E, 23 Apr 1981, A.B. Rose, AM KS115258; 1 ma., Gerringong, Mayflower Retirement Village, 34°45'S 150°50'E, 21 Mar 1991, G. Wishart, AM KS91402; 1 ma., Myall R, site A1, 9 Feb 1974, AMS KS; 1 ma., Mororo State Forest, 29°19'06"S 153°14'28"E, 1 Feb 1997, pitfall, A. York, AM KS74425.

Diagnosis. Males are unique in having a long bowed palpal tibia (Figs 21b, 22a), and females in having a trianguloid epigyne (Fig. 22c).

Description. Holotype male QM S67741. Carapace 7.00 long, 6.12 wide. Abdomen 5.29 long, 3.65 wide. Total, 12.5.

I: 7.18; 3.59; 6.94; 8.24; 4.35; 30.29. II: 7.18; 3.53; 7.12; 3.18; 3.94; 24.94. III: 7.24; 3.00; 6.12; 7.71; 3.59; 27.65. IV: 8.24; 3.18; 6.18; 8.53; 4.00; 30.12. Palp: 5.06; 2.47; 3.59; 2.41; 13.53.

Colour. Carapace red brown with broad white marginal band of hair widest anterior to fovea. Abdomen dorsally brown with narrow fringe around dorsal edge, ostiate region pallid, otherwise with darker reticulations. Abdomen without ventral pattern. *Eyes.* Group width/headwidth=0.58 through PLE, 0.53 through mid-eye group. OQ front, back, long: 47, 75, 45. MOQ front, back, long: 25, 31, 28. AME–AME, 3; AME–ALE, 5; PME–PME, 7; PM-PL, 14. AME: ALE: PME: PLE, 10: 9: 12: 15. PER in two lines without overlap. STC on I with 7 long teeth; ITC bare. *Spines.* Legs I, II: fe p5d3r5; pa p1 apical 1 triangular, r1; ti p2d2r2v.2.2.2.2; me p2r2v2.2 + distal whorl of 4. Leg III, IV: as

above but, pa p1d1 (apical)r1; ti p2d2r2v.2.2.2; me p2r2 v1.1.1.1 + distal whorl of 4. Palp: fe p1d1.1.1.2r2; pa p1; ti p1. Patellae with triad but apical spine weak, ventral spines on tibiae and metatarsi I, II non-overlapping. Palp (Figs 21b, 22a, b). Tibia of male palp long,1.06 times longer than cymbium, bowed prolaterally for length, with large VTA with serrate retrolateral edge; simple thumb-like RTA set retrolaterally. Cymbium broad with short apical cone and small retrobasal process. Transverse component of tegulum directed diagonally to base, DTP bent, thumb-like with distal "limb" concave prolaterally; MA large flared, anvil-shaped, extends distal of DTP with long curving hook basally overlying it; fulcrum and conductor small, distal.

Female QM S67769. Carapace 9.17 long, 7.67 wide. Abdomen 8.83 long, 5.83 wide. Total, 18.00.

I: 7.44; 3.84; 6.32; 5.44; 2.80; 25.84. II: 7.84; 4.00; 6.48; 5.52; 2.48; 26.32. III: 7.36; 2.40; 5.76; 5.44; 2.56; 23.52. IV: 8.56; 3.92; 7.20; 8.16; 3.60; 31.44. Palp: 3.44; 1.92; 1.76; 2.56; 9.68.

Carapace dark with narrow dark edge and wide pale submarginal band. Abdomen dark with indistinct pattern; venter faded but with central dark field wth 2 lines of small sigilla. *Eyes.* Group width/headwidth=0.60 through PLE, 0.40 through mid-eye group. OQ front, back, long: 34, 68, 37. MOQ front, back, long: 22, 29, 22. AME: ALE: PME: PLE, 9: 5: 12: 11. PLE at posterior end of caput shoulder. AER with 40–50% overlap; PER in two lines separated by half of PME diameter. Chelicerae, 2p, 4r. STC with *ca.* 6–8 teeth; ITC, 0. Scopula for distal 0.6 of tibia I, and length of metatarsi and tarsi I, II. Group of long hairs (not tufts) only below *Claws.* Palp: fe p1d1.1.1.2r1; pa p1d1 (all weak bristles); ti p2d2; ta pv2 rv2. Pedal patellae with p1r1 all weak. All spines short, weak. Epigyne (Fig. 22c, d). Overall shape trianguloid, slightly longer than wide. Lateral lobes with long anteriorly convergent ridge; spermathecae occupy 0.33 of length, simple lobes in short gamma-shape.

Distribution. Known only from several coastal areas in north-eastern New South Wales (Tweed River) north to heath swamps on Moreton Island and Cooloola, as well as the rainforest in the Conondale Range, in Queensland.

Dolomedes flaminius L. Koch, 1867
(Figs 23a, b, 24 a–c. Map 2a)

Dolomedes flaminius L. Koch, 1867: 197; L. Koch, 1876: 877, pl. 75, figs 4, 4a, 4b; Rainbow, 1911: 263; Davies, 1985: 103.

Material Examined. Queensland: holotype, male, "Brisbane", ZMH, examined.

Diagnosis. The male of *Do. flaminius* shares with males of *Do. facetus* and the New Caledonian *Do. neocaledonicus* the palpal tibia being slightly shorter (*ca.* 0.83) than the cymbium (Fig. 24a–c), the DTP is large and trianguloid with a similar prolateral basal mound (Fig. 24a); the median apophysis lacks the retrolateral vane (Fig. 24a) and the palp is short unlike those of the *Do. albicomus* group, the ventral abdomen lacks pattern and the dorsal abdomen has pallid spots and a median pallid zone (Fig. 23a). The only clear differences between males of *Do. flaminius* and *Do. facetus* and *Do. neocaledonicus* is in the retrolateral view of the RTA which is a low ridge in *Do. flaminius* (Fig. 24c) but a ridge with two long prongs (Fig. 10e) in *Do. facetus* and *Do. neocaledonicus,* the tegulum is shorter, broader and more transverse (*cf.* longer, slender, diagonal tegulum of *Do. facetus).* However, a further difference is in the dorsal abdominal pattern (but see Remarks) of *Do. flaminius*, with the full length pallid sinuous band, a pattern unlike any in Australia, New Zealand or USA. Males differ from those of *Do. briangreenei* in the large straight trianguloid DTP. Males of *D. flaminius* differ from those of *D. neocaledonicus* in the wider shallower RTA and from *Do. titan* in the short palpal tibia and absence of a retrolateral process on the median apophysis. Females are unknown.

Description. Holotype male ZMH. Carapace 5.09 long, 4.56 wide. Abdomen 4.56 long, 2.63 wide. Total, 9.7.

Colour. Carapace redbrown with faint paler margins; no indication of medial pallid line as in *Do. facetus.* Abdomen dorsally with darker flanks and undulating brown pallid zone medially; venter pallid without pattern. Palp (Fig. 24a–c). Cymbium *ca.* 1.2 times longer

than tibia. RTA a low long undulating ridge with longer lobe on dorsal edge, viewed ventrally, appears long conical; 4 long bristles on retroventral tibia; VTA small rounded trianguloid; retroventral cymbial flange almost triangular; massive distal tegular process irregularly triangular with unsclerotised basal zone; median apophysis smoothly sigmoidal without retrolateral process basally.

Remarks. The stated type locality of *Dolomedes flaminius* is Brisbane. However, no further material resembling the type has been found. As is sometimes the case with 19th century Australian localities (e.g. see Raven 1982), the stated locality represents only the port of departure rather than the collecting locality. This may explain why no further material has been taken.

To date, no males assignable to *Do. flaminius* have been found in the Brisbane area where at least five other *Dolomedes* species (*Do. vicque* sp. nov., *Do. venmani* sp. nov., *Do. facetus, Do. albicomus* and *Do. briangreenei* sp. nov.) occur in the area. Of those, males of *Do. flaminius* are most similar to those of *Do. facetus* with which they share the relatively short palpal tibia and the shallow broad bifid RTA (Fig. 24c), the former also shared with *Do. vicque* and *Do. briangreenei.*

Substantial differences in Koch's localities and the actual distribution of species have been documented, e.g. in *Arbanitis longipes* (L. Koch 1873), the stated type locality was Bowen whereas it is actually Brisbane (Raven & Wishart 2006); in *Uliodon frenatus* (L. Koch 1873) the stated type locality was Australia but the genus is endemic to New Zealand (Raven & Stumkat, 2002). Thus, the actual locality for *Do. flaminius* may not be Brisbane or even Australia. A male and female from Kairiru Island, Papua New Guinea (AM KS8039, KS8016, here listed in *Do. facetus*) have the most similar palpal bulb and RTA to those of the holotype of *Do. flaminius* but the abdominal pattern is quite different.

As noted in the diagnosis, the dorsal abdominal pattern of *Do. flaminius*, with the full length pallid sinuous band (Fig. 23a), is unlike any known pisaurid in Australia, New Zealand (Vink & Dupérré 2010) or USA (Carico 1973). In most species, the central medial pallid zone is a dagger-shaped area overlying the heart and thus confined anteriorly (e.g. Fig. 21a). The exception is in *Do. facetus*, the nearest species to *Do. flaminius*, in which the pattern is also quite different with two lines of white spots running the length of the abdomen (Fig. 8a).

The specimen in the vial labelled holotype (Figs 23a, b, 24a, b) of *Dolomedes flaminius* in Hamburg differs from that figured by Koch in several ways.

Koch's figure of the male shows:

- broad white lateral carapace sashes (as in *Do. briangreenei*, Fig. 17a) whereas Fig 23a shows narrow carapace sashes.
- narrow white medial band on carapace (as in *Do. facetus*) whereas Fig. 23a shows such a band only centrally.
- the dorsal abdominal pattern is dark with white flanks and dorsally paired lines then dots posteriorly (as in *Do. facetus*) whereas Fig. 23a shows the paired lines and spots flanking a pallid undulating central band, as in *Do. neocaledonicus*.
- strong similarities in the palpal bulb and sclerites, especially the large DTP, with *Do. facetus* and *Do. neocaledonicus* however,
- the median apophysis extends beyond DTP whereas in other similar species it is never long. However, the artist may have conflated the fulcrum and median apophysis making the latter seem more extensive.
- the RTA is long and pointed with sinuous distal edge whereas Fig 24a shows a low ridge with a small lower lobe and longer dorsal lobe which together, from some angles, can appear pointed but not with distal processes.
- the VTA is large and square in distal shape (as in *Do. neocaledonicus*) whereas Fig. 24a shows the VTA a small rounded cone.

Distribution. The holotype was putatively from Brisbane and no further material matching

it has been found since in the Brisbane area, one of the best sampled areas for *Dolomedes*, or elsewhere. Although the bulb and RTA are similar to that of the New Caledonia *Do. titan*, they differ substantially in the relative length of the palpal tibia to the cymbium. The most likely possibility is that *Do. flaminius* may not be Australian.

Dolomedes wollemi sp. nov.

(Figs 3a, b, 25 a, b, 26a–g. Map 2b)

Etymology. The species epithet is a noun in apposition from the infamous Wollemi pine (*Wollemia nobilis* Jones, Hill & Allen, 1974, Araucariaceae) and the National Park which houses it.

Material examined. New South Wales: Newnes, Wolgan Valley, 33°10′19.1″S 150°14′22.5″E, 21 Dec 2016, J. Wolff: holotype male, AM KS126569; 2 fem., same data, AM KS126570, KS126572; 1 ma., Gordon Western Traps, 33°44′S 151°09′E, 23 Oct 1982, Pitfall, C. Horseman, AM KS10448; 1 ma., Lindfield, 33°47′S 151°10′E, 22 Dec 1968, N. Allan, AM KS2696; 1 ma., Roseville, 33°47′S 151°12′E, 24 Apr 1998, S. Manners, AM KS57124; 1 ma., Nahrwongah, AM K11959; 1 ma., 1 fem., Parsons Creek, upstream of Terrys creek, 32°44′24″S 150°56′08″E, 16 Oct 2012, G. Theischinger, AM KS120611.

Diagnosis. The male palp is very similar to that of *Do. albicomus* in that tibia is very long but males differ from those of all species in the group in lacking the flange on the retrobasal edge of the median apophysis (Fig. 26a). Females are similar to those of *Do. vicque* sp. nov. and *Do. briangreenei* sp. nov. in the presence of cones or hooks on the epigyne (Fig. 26e, f) but differ in that the epigyne is relatively wider and all of the spermathecal ducts are similarly wide.

Description. Holotype male AM KS126569. Carapace 5.84 long, 4.80 wide. Abdomen 6.00 long, 4.40 wide. Total, 11.84.

I: 7.68; 2.96; 7.60; 7.44; 3.92; 29.60. II: 7.28; 2.96; 7.04; 6.00; 3.60; 26.88. III: 6.88; 2.40; 6.00; 6.24; 2.80; 24.32. IV: 7.92; 2.64; 7.36; 8.32; 4.00; 30.24. Palp: 2.96; 2.16; 2.16; 2.24; 9.52.

Carapace dark brown with broad brown margins, sublateral band of white hair widest at caput–thorax junctions extends narrowly to clypeus. Abdomen dark, ostiate "dagger" darker edge with white flanks form "crown", venter centrally pallid. *Eyes.* Gentle caput shoulder; PLE at mid-curve. AME on common tubercle. Group width/headwidth=0.75 through PLE, 0.62 through mid-eye group. OQ front, back, long: 28, 47, 26. MOQ front, back, long: 21, 23, 14. AME: ALE: PME: PLE, 6:5:10:10. PER cuts through back of caput shoulder. AER with 20–30% overlap; PER in two well separated lines. STC with 8 teeth; ITC 0. *Spines.* Palp: fe p1d1.1.1.2r1; pa p1d1; ti 0. Palp (Fig. 26a–d). RTA with retrodorsal rhomboidal keel, and cluster of strong bristles ventrally; DTP digitiform to thumb-like; tegulum transverse; median apophysis strongly flared over DTP and lacks any retrobasal keel.

Female AM KS126570. Carapace long 10.67, 8.33 wide. Abdomen 10.33 long, 6.67 wide. Total, 21.0.

I: 8.24; 4.08; 7.20; 6.56; 3.60; 29.68. II: 8.88; 4.48; 7.12; 6.64; 3.60; 30.72. III: 8.00; 4.24; 6.56; 6.48; 3.28; 28.56. IV: 9.20; 3.60; 7.28; 8.48; 4.56; 33.12. Palp: 4.16; 2.08; 2.48;2.56; 11.28.

Colour. Carapace dark brown with dark brown edges, jagged submarginal edge with pallid midline. Abdomen dorsally dark, ostiate area dagger-like; ventral abdomen mottled to well defined anterior field with faint sign of 2 pallid lines. *Eyes.* Group width/headwidth=0.50 through PLE, 0.45 through mid-eye group. OQ front, back, long: 45, 67, 41. MOQ front, back, long: 22, 33, 28. AME: ALE: PME: PLE, 9: 7: 13: 12. PER in two lines well separated by 0.3 of PME diameter; AER with 50% overlap. STC with 7 long teeth; ITC bare. Scopula lateral on metatarsi and tarsi I, II, narrow lateral bands on tarsi III. *Spines.* Pedal patellae with triad. Palp: fe p1d1.1.1.2r1; p1d1r1w; ti p1r1; ta p2. Epigyne (Fig. 26e–g) broadly rounded with median field for 5/6 of length with low distal septum; two low cones or hooks, viewed axially from behind, on median field; CD strongly overlaps with second coil and that of similar width to third.

Distribution. Western edge of the Great Divide at Blackheath and nearby Wollemi National Park and presumably between them.

Dolomedes mankorlod sp. nov.
(Figs 7b, 27a–d; Map 2c)

Etymology. The species epithet is a noun in apposition from aboriginal name of the area.

Material examined. Type. Northern Territory: holotype male, female paratype, Mankorlod, south of Maningrida, Arnhem Land, August 2013, R. Raven, MAGNT A004617.

Diagnosis. Males differ from those of *Do. albicomus* in the median apophysis with small trianguloid process retrolaterally on basal portion (Fig. 27a), and from that of *Do. instabilis* in the DTP narrowing strongly from base to tip (Fig. 27a), and from both in the palpal tibia is only slightly than cymbium. In the female, the epigyne is very similar to that of *Do. instabilis* but females differ in having a distinct scopula on tibia I (Fig. 7b) and the lateral epigynal ridges curve smoothly rather than unevenly as in *Do. instabilis*.

Description. Holotype male MAGNT A004617. Carapace 6.80 long, 5.92 wide. Abdomen 6.00 long, 3.44 wide. Total, 12.80.

I: 8.00; 3.52; 7.36; 7.20; 4.16; 30.24. II: 8.00; 2.96; 6.56; 6.80; 4.00; 28.32. III: 7.60; 3.20; 6.08; 6.24; 2.96; 26.08. IV: 8.56; 3.20; 7.60; 6.32; 5.12; 30.80. Palp: 5.12; 1.92; 2.72; 2.40; 12.16.

Colour. Carapace red brown centrally with cover of fine black hairs, narrow black edges with broad band of white hair widest beside caput. Abdomen dark brown with fringe of white hairs laterally; venter darkly mottled, medially mottled. *Eyes.* Group width/headwidth=0.63 through PLE, 0.56 through mid-eye group. OQ front, back, long: 33, 55, 32. MOQ front, back, long: 16, 25, 19. AME: ALE: PME: PLE, 7: 5: 11: 10. PER cuts through mid-curve of caput shoulder. AER with 15–20% overlap; PER in two well separated lines. Chelicerae 2p, 4r. Tarsi I–IV ventrally with black thorns. *Spines.* Palp: fe p1d1.1.1.2r1; pa 0; ti 0. Palp. Tibia longer than cymbium; VTA low curved keel; tegulum transverse; DTP thumb-like, narrowing strongly from base to tip; median apophysis with small trianguloid process retrolaterally on basal portion; RTA a small low ridge (Fig. 27b).

Allotype female MAGNT. Carapace 8.16 long, 7.04 wide. Abdomen 8.80 long, 5.44 wide. Total, 17.0.

I: 7.60; 3.44; 6.64; 5.84; 2.96; 26.48. II: 8.08; 3.84; 6.64; 5.92; 2.72; 27.20. III: 7.60; 3.52; 6.24; 5.76; 2.88; 26.00. IV: 8.32; 3.76; 7.76; 8.24; 3.52; 31.60. Palp: 3.52; 1.76; 2.40; 2.80; 10.48.

Colour. Carapace dark red brown with broad dark edges, yellow submarginal band, jagged and discontinuous at caput. Abdomen dorsally dark brown with dark foliate dagger-like area with irregular pallid spots anterolaterally and posterior laterally. Venter laterally mottled with dense central field and 4 lines of pallid areas converging. Femora laterally with large mottling (Fig. 7b, inset). *Eyes.* Group width/headwidth= 0.65 through PLE, 0.44 through mid-eye group. OQ front, back, long: 40, 65, 40. MOQ front, back, long: 21, 30, 25. AME: ALE: PME: PLE, 8: 8: 13:13. PER just form two lines; AER with 50% overlap. STC with 7 long teeth; ITC bare. Scopula on lateral tibia I (Fig. 7b) and on metatarsi and tarsi I–III. *Spines.* Palp: fe p1d1.1.1.2r1; pa p1d1.1; ti p2d1; ta pv2rv2. Epigyne (Fig. 27c, d). Overall shape 1.17 times longer than wide. Edges of lateral lobes curve smoothly. Median field (excluding septum) occupies 0.59 of overall length. Internally, two closely adpressed lobes with inner lobe longer and wide.

Distribution and habitat. Known only from Mankorlod, an area of open forest just south of Maningrida, Arnhem Land, Northern Territory.

Dolomedes karijini sp. nov.
(Figs 28a–d, 29a–d. Map 2d)

Etymology. The species epithet is a noun in apposition from the National Park which houses it.

Material examined. Types. Western Australia: holotype male, Karijini Natiotnal Park, Dales Gorge (Circular Pool), 22°28′33″S, 118°34′43″E, 15 Mar 2015, C. Stevenson, R. Bray, WAM T135513. Paratype female, same data but, surface of shallow pool, 18 Mar 2015, J. Huey, M. Harvey, WAM T135645.

Diagnosis. The male differs from that of *Do. mankorlod* in that the retrobasal flange on the median apophysis is rounded (Fig. 28b) rather

than trianguloid. Females differ from those of *Do. instabilis* in the shorter ridged median field (Fig. 29c) and the non-overlapping spermathecal ducts (Fig. 29d).

Description. Holotype Male WAM T135513. Carapace 7.44 long, 6.80 wide. Abdomen 6.72 long, 5.52 wide. Total, 14.2.

I: 10.00; 4.17; 9.00; 8.83; 5.67; 37.67. II: 10.00; 4.00; 8.33; 7.83; 4.83; 35.00. III: 8.83; 3.50; 7.50; 7.17; 3.83; 30.83. IV: 10.17; 3.00; 8.50; 8.67; 4.83; 35.17. Palp: 5.50; 2.00; 3.17; 3.00; 13.67.

Colour. Carapace red-brown with white median line, wide black margins with wide band of white hair extending to but not around clypeus. Abdomen redbrown with broad pallid flanks, mottled dorsally; venter with defined field with at least two wide pale lines. *Eyes.* Group width/headwidth=0.64 through PLE, 0.52 through mid-eye group. OQ front, back, long: 38, 58, 33. MOQ front, back, long: 21, 30, 20. AME: ALE: PME: PLE, 10:6:11:11. PER just forms two lines; AER with 20% overlap. Chelicerae with one small and 2 large teeth on promargin, 4 on retromargin. STC on I with 5–6 long teeth; ITC bare. Scopula absent. *Spines.* Palp: fe p1d1.1.1.2r1; pa p1 weak; ti 0. Palp (Fig. 28a–d). Tibia *ca.* 1.2 times longer than cymbium (Fig. 28a). Median apophysis with triangular retrobasal flange; retrodistal flange flared widely over DTP (Fig. 28b). DTP curved banana-like; tegulum transverse. Conductor and fulcrum short. VTP rectanguloid. RTA a low ridge with small terminal lobes (Fig. 28c).

Female WAM T135645. Carapace 12.17 long, 10.17 wide. Abdomen 10.33 long, 7.33 wide. Total, 22.50.

I: 11.17; 5.83; 9.50; 8.00; 4.00; 38.50. II: 11.33; 6.17; 9.67; 8.33; 4.17; 39.67. III: 11.17; 4.50; 8.67; 7.50; 3.83; 35.67. IV: 11.67; 5.17; 10.33; 13.17; 4.67; 45.00.Palp: 4.33; 2.50; 3.00; 3.67; 13.50.

Colour. Carapace dark red-brown, dark narrow margin with mottling near caput edge, deeply sinuous orange brown submarginal band, median line full length broad in parts. Abdomen dorsally, fawn with ostiate region darker, dagger-like and medially pallid, broad irregular pallid zones lateral of that and darkly mottled flanks; ventral pattern of two wide faint lines centrally in paler median V-shape formed by dark lateral faces. *Eyes.* AME on common tubercle. Group width/headwidth=0.62 through PLE, 0.44 through mid-eye group. OQ front, back, long: 54, 85, 43. MOQ front, back, long: 25, 36, 23. AME: ALE: PME: PLE, 10:8:14:15. PER in two lines separated by 0.29 of PME diameter; AER with 50% overlap. Chelicerae with 2 large teeth, one bicuspid on promargin, 4 on retromargin. Most claws broken, 4–5 teeth evident on STC and palp; ITC bare. Scopula laterally for length of tibia I, weak and distal only on tibia II, lateral on metatarsi and tarsi I–IV but only for distal half on IV; dense hair clusters around claws. *Spines.* Palp: fe p1d1.1.1.2r1; pa p1d1; ti p2d1r1; ta p2r2. Epigyne (Fig. 29 c, d) wider than long with short procurved ridged median field (Fig. 29c) and long septum; spermathecal ducts similar in size and non-overlapping.

Distribution. Known only from Karijini National Park, north western WA.

Dolomedes alexandri sp. nov.
(Figs 30a–c, 31a, b. Map 2e)

Etymology. The species epithet is in honour of the late Alexander (Sandy) Roy whose steadfast and thorough contributions in sorting and managing the Australian National Insect Collection of arachnids was most appreciated by Australian arachnologists.

Material examined. Types. Australian Capital Territory: holotype male, Lees Ck, Brindabella Ranges, pitfall, 29 May 1981, C. Dickman, ANIC 42: 001795. Paratype, Victoria, 1 ma., penult fem., East Gippsland, Wrong Ck Trail, Rodger River Forest Block, 37°18'S 148°31'E, 1 Feb 1983, pitfall, D. Allen, AM KS87150.

Diagnosis. Males differ from those of all other species of Australian *Dolomedes* by the short barrel-shaped palpal tibia (Figs 30a, 31a). Female unknown.

Description. Holotype male ANIC 42: 001795. Carapace 8.24 long, 6.64 wide. Abdomen 6.40 long, 4.00 wide. Total, 14.64.

I: 7.36; 3.60; 6.88; 7.36; 4.64; 29.84. II: 7.20; 3.28; 6.64; 7.20; 4.24; 28.56. III: 7.36; 2.64; 6.08; 6.24;

3.44; 25.76. IV: 7.36; 2.64; 6.08; 6.24; 3.44; 25.76. Palp: 3.76; 1.44; 1.36; 3.36; 9.92.

Condition poor. Carapace redbrown with longitudinal pallid midline, darker striae, narrow dark margins with broad submarginal band of white hairs, band widest at caput shoulder. Abdomen collapsed, dark with white "shoulders"; venter pattern indiscernible. *Eyes.* Group width/headwidth=0.63 through PLE, 0.54 through mid-eye group. OQ front, back, long: 40, 56, 34. MOQ front, back, long: 23, 30, 27. AME: ALE: PME: PLE, 9, 8, 13, 12. PLE mid-caput shoulder curve; AER in 2 separated lines; PER in two slightly separated lines. STC with ca. 8 teeth; ITC bare. Scopula only on metatarsi and tarsi I. *Spines.* Palp: fe p1d1.1.1.2r1; pa p1(d1r1); ti p2d1. Patellar spines p1, bristles d1r1. Palp (Figs 30a–c, 31a, b). Male palpal cymbium clearly longer, barrel-shaped; DTP long, narrows strongly in distal third, directed diagonally across distal relatively smaller median apophysis, basal portion of tegulum long, only slightly diagonally upward; retroventral cymbial corner narrowly and gradually flared; tibia with short basal "neck" enlarging quickly to barrel-shape (Fig. 30a); RTA subdistal, long, flared with long narrow groove apically with slender lobe and smaller subapical "teeth".

Distribution. Known from the Brindabella Ranges, Australian Capital Territory and East Gippsland, Victoria.

Dolomedes lizturnerae sp. nov.
(Figs 32a–c, 33a–e. Map 2f)

Etymology. The species epithet is in honour of Elizabeth (Liz) Turner who long served as collection manager/curator of Arachnology at the Tasmanian Museum and Art Gallery.

Material examined. Tasmania: Murphys Flat, 42.75275°S 147.15667°E, 25 Mar 2010, Bush Blitz, R. Raven: holotype male, TMAG J4124; female, same data, TMAG J4125; 1 ma., East Risdon, 42°50′S 147°21′E, 31 Jan 1961, J.L. Hickman, AM KS29155; 1 ma., Risdon Creek, 42°50′S 147°19′E, 20 Oct 1967, J.L. Hickman, AM KS29160.

Diagnosis. The male differs from those of the *D. albicomus* species group by a large distal hook on the retrolateral median apophysis (Fig. 32a). Females of *Do. lizturnerae* differ from those of *Do. instabilis* in the relatively wider overall shape of the epigyne (Fig. 33d), the relatively shorter septal area (*ca.* one third overall length) and the middle loop of the spermathecal ducts (Fig. 33e) is clearly longest and longitudinal rather than diagnonal as in *Do. instabilis.*

Description. Holotype Male TMAG J4124. Carapace 5.76 long, 4.88 wide. Abdomen (shrivelled) 4.32 long, 3.40 wide.

Palp: 4.82, 2.08, 2.78, 1.80, 11.18. *Colour.* White band on lateral ceph narrow to base of caput then quickly widens in undulating band to about mid fovea where it narrows again. Abdomen dorsally brown, no pattern; ventrally pallid. *Eyes.* Eye group width/headwidth=0.65 through PLE, 0.53 through PME. *Spines.* Legs I, II: fe p5d3r5; pa p1r1; ti p2d2r2v.2.2.2.2; me p2r2v2.2 + distal whorl of 4. Leg III, IV: as above but, pa p1d1 (apical)r1; ti p2d2r2v.2.2.2; me p2r2 v1.1.1.1 + distal whorl of 4. Palp: fe p1d1.1.2r2; pa 0; ti p1r1. Palp (Fig. 32a–c). Very long tibia widens gradually to retrolateral face with RTA. RTA a low sinuous ridge with subcentral blunt tooth. Large distal hook on retrolateral median apophysis (Fig. 32a).

Female TMAG J4125. Carapace 7.17 long, 5.83 wide. Abdomen 6.67, 3.17 wide.

I: 5.92, 3.33, 5.00, 4.00, 2.50, 20.75. II: 6.17, 3.17, 4.83, 4.17, 2.33, 20.67. III: 5.58, 2.83, 4.17, 4.00, 2.25, 18.83. IV: 6.75, 3.00, 5.83, 6.17, 2.92, 24.67. Palp: 2.92, 1.42, 1.83, –, 2.33, 8.50.

Carapace. With dark edge. Abdomen shrivelled, dorsally dark with digitiform pallid mark anteriorly. *Eyes.* PER about equal in size. AME–AME >AME–ALE. *Legs.* Scopula on metatarsi I, II in bands; entire on tarsi I, II, widely divided on III. 6 teeth on STC, smallest basally. ITC bare. *Spines.* I & II: fe pv1p4d3r5; pa p1r1; ti p1.1r1.1v2.2.2.2; me p2r2v2.2.3. III & IV: fe p5d3r5; pa pd1 apical r1; ti p2d.1.1r2v2.2.2; me p1.1.2r1.1.2v2.2.3. *Palp.* fe p1d1.1.1.2r1; pa p1d1; ti p2r1; ta p2.1r1.1. *Epigyne* (Fig. 33d, e). CO transverse ridge forms median scape in anterior third; spermathecae one large longitudinal duct with smaller spheroidal ducts on entry and exit.

Distribution. Known from Murphys Flat and East Risdon, southern Tasmania.

Dolomedes pedder sp. nov.
(Fig. 34a, b. Map 2e)

Etymology. The species epithet is a noun in apposition from the type locality, Lake Pedder, which was "drowned" in 1972 for a hydroelectric dam on the Serpentine River, southwestern Tasmania.

Material examined. Type. Tasmania: holotype male, Lake Pedder, 43°00'S 146°08'E, 1 Mar 1972, C. Horseman, AM KS107495.

Diagnosis. The male is most similar to those of *Do. vicque* sp. nov. but differs in the four-pointed retrolateral tibial apophysis (Fig. 34b). Females are unknown.

Description. Holotype Male AM KS107495. Carapace 5.84 long, 4.88 wide. Abdomen 5.60 long, 2.96 wide. Total, 11.4.

I: 6.00, 2.64, 5.44, 5.44, 3.92, 23.44. II: 5.84, 2.56, 5.20, 5.04, 2.88, 21.52. III: 5.44, 2.48, 4.48, 4.64, 2.08, 19.12. IV: 6.80, 2.80, 6.16, 6.24, 3.76, 25.76. Palp: 3.84, 1.36, 1.52, –, 2.08, 8.80.

Colour. Carapace brown with narrow submarginal white bands, widest at half length. Abdomen dorsally dark with pale ostiate region and white flanks; venter entirely dark without pallid lines. *Eyes.* Group width/headwidth= 0.65 through PLE, 0.52 through mid-eye group; caput shoulder very gradual. MOQ front, back, long: 27, 47, 28. MOQ front, back, long: 16, 25, 15. PER in two lines well separated by 0.7 of PME diameter; AER with 60% overlap. Chelicerae with one small and 2 large teeth on promargin, 4 on retromargin. STC with *ca.* 10 long teeth; ITC with 1 tooth. Scopula absent on tibiae–tarsi. *Spines.* Pedal patellae with triad. Palp: fe p1d1.1.1.2r1; pa p1d1.1; ti p1d1. Palp (Fig. 34a, b). Tibia of male palp shorter than cymbium. Retrobasal cymbium widely flared. DTP very broad, trianguloid. MA slender without retrobasal process. RTA retrolateral with three separate prongs, the most dorsal deeply bifid.

Distribution. Known only from Lake Pedder and presumably surrounding areas, south-western Tasmania.

NEW CALEDONIAN *DOLOMEDES*

Dolomedes titan Berland, 1924
(Figs 35, 36a–e. Map 3a)

Dolomedes titan Berland, 1924: 240.

Material examined. New Caledonia: holotype female, Mt Canala, 700 m, 3 Nov 1911, coll. Sarasin and Roux, MNHN, examined; 1 fem., Oubatche, under overhang, 1 Nov 1988, R. Raven, QM S13542; 2 fem., Col d'Amoss, 20°18'S, 164°25'E, 13 Feb 1993, R.J. Raven, QM S37690, S38060, 30678; 1 ma, 1 fem. (photograph), Mt Mou, 380–400 m, rainforest, 24 Feb 1993, R. Raven, MNHN; fem., juvs, Grottes d'Adio, near Poya, 21°15'S, 165°14'E, Dec–Jan 1965, G,F. Gross, SAMA NN13655.

Diagnosis. Males differ from those of *Do. instabilis* in the slightly smaller retrobasal process on the median apophysis (Fig. 36a) and the more elevated RTA(Fig. 36c). Females differ from those of *Do. instabilis* in the epigyne having a slightly broader median field (Fig. 36d); internally, the ducts are more slender and more widely spaced (Fig. 36e).

Description. Male QM S30678. Carapace 9.50 long, 7.83 wide. Abdomen 7.50 long, 3.83 wide. Total, 17.0.

I: 12.83; 5.33; 12.33; 12.50; 7.17; 50.17. II: 13.17; 5.33;12.00; 11.50; 6.17; 48.17. III: 11.83; 5.00; 10.17; 10.17; 5.17; 42.33. IV: 12.33; 5.00; 12.50; 13.83; 6.83; 50.50. Palp: 7.17; 2.50; 3.50; 3.17; 16.33.

Colour. Carapace red-brown with wide lateral band, widest anterior to mid-fovea. Abdomen faded brown, venter pallid. *Eyes.* Group width/ headwidth=0.65 through PLE, 0.54 through mid-eye group. OQ front, back, long: 43, 67, 40. MOQ front, back, long: 21, 34, 22. AME: ALE: PME: PLE, 9: 7: 12: 15. PER well behind, small, caput shoulder. AER with 60% overlap; PER two well separated lines. Chelicerae: p2, r4. Legs very long but tarsi not pseudosegmented. Femur IV unmodified. Tarsi long, slender, slightly bowed, not curved, no scopula. STC with *ca.* 8 teeth; ITC bare. Scopula absent. *Spines.* Pedal patellae: d1 basal, pr1r1. Palp: fe p1d1.1.1.2r1.1; pa p1, d1; ti p1d1; ta 0. Palp (Fig. 34a, b). Dense group of 40–50 strong bristles on retroventral tibia; tibia much longer than cymbium. RTA set retrodorsally, with long low collar with small bifid ventral lobe and long

pointed distal lobe; tegulum transverse, DTP thumb-like; median apophysis with triangular retrobasal process on narrow "neck".

Female QM S13542. Carapace 12.00 long, 9.50 wide. Abdomen 9.67 long, 5.83 wide. Total, 21.67. I: 12.00; 5.83; 12.33; 10.67; 5.50; 46.33. II: 13.17; 5.83; 11.83; 11.17; 5.83; 47.83. III: 12.50; 5.00; 11.00; 10.33; 5.17; 44.00. IV: 14.33; 5.83; 13.33; 14.00; 12.00; 59.50. Palp: 4.83; 2.67; 3.67; 4.00; 15.17.

Colour. Carapace yellow bown with light brown margins posterior to caput; broad pallid band extends to clypeus; medial area darkest on edges not centrally; 2 dark ovoid areas in prefoveal area. Abdomen dark with pallid ostiate area, light shoulders; venter pallid contrasts to flanks. *Eyes.* Group width/headwidth=0.63 through PLE, 0.51 through mid-eye group. OQ front, back, long: 22, 38, 21. MOQ front, back, long: 12, 19, 12. AME: ALE: PME: PLE, 11: 8: 15: 16. PER cuts through mid-curve of caput shoulder. AER with 15–20% overlap; PER two well separated lines. Chelicerae 2p, 4r; no PTF. STC with 6 teeth; ITC bare. *Spines.* Palp: fe p1d1.1.1.2r1; pa p1r1d1; ti p2d1.1; ta pv2rv2. Epigyne cordate with median field confined to basal third; internally, ducts slender and well separated.

Distribution. Known only from New Caledonia.

Remarks. Despite their large size, females and males of *Do. titan* lack the pseudosegmented tarsi of *Megadolomedes*. The long palpal tibia and retrobasal process on the median apophysis places *Do. titan* firmly in the *Do. albicomus* species group.

Dolomedes neocaledonicus Berland, 1924
(Fig. 37a–c. Map 3b)

Dolomedes neocaledonicus Berland, 1924: 241, figs 189–191, syntyes male and female, MNHN 3.851, examined. Species actually attributed to Simon as "*Dolomedes neocaledonicus* E. Simon n. sp." as it was so named in Simon's collection (Berland, 1924: 241).

Material Examined. Types. New Caledonia: holotype male, 2 paratypes females, Noumea, MNHN 3.851.

Other Material Examined. New Caledonia: male and several juveniles, Canala, Oct 1911, coll. Sarasin and Roux, MNHN; 1 fem., base of Mandjelia, 17 Feb 1993, R. Raven, QM S108408; 1 ma., Baie Nure, Dumbea, 23 Mar 1980, L. Bigot, QM S13826.

Diagnosis. Males differ from those of *Do. facetus* in the widely spaced and slightly dissimilar RTA which has a second lobe on the ventral process. The epigynes of females look very like those of *Do. facetus* but differ in being less angular and more rounded and all spermathecal ducts are broader.

Description. *Male* QM S13826. Carapace 4.78 long, 4.41 wide. Abdomen 5.65 wide, 3.35 long. Total 10.5.

I: 6.88, 2.75, 6.63, 6.63, 3.25, 26.13. II: 6.38, 2.75, 5.88, 5.63, 3.13, 23.75. III: 6.25, 2.50, 5.13, 5.38, 2.88, 22.13. IV: 7.50, 2.75, 6.25, 7.25, –, 23.75. Palp: 3.83, 1.58, 1.58, –, 2.75, 9.75.

Colour. Carapace with narrow white band on margin, darker centrally. Dorsal abdomen pattern like *Do. facetus*. *Eyes.* Group width/headwidth=0.55 through PLE, set well behind caput shoulder, 0.54 through mid-eye group. OQ front, back, long: 30, 51, 27. MOQ front, back, long: 16, 24, 17. AER with 15% overlap; PER two separated lines ca. 0.3 PME diameter apart. *Spines.* Palp: fe p1d1.1.2r1; pa p1d.1.1; ti p2d1. Palp (Fig. 37b, c). Tibia enlarged distally with rectanguloid ventral apophysis; RTA lateral, not dorsally, placed, two low lobes set well apart but short, ventral lobe with lower ledge. DTP broad triangular, median apophysis with narrow base and flares broadly; retrobasal cymbium enlarged with thumb-like process.

Female (Fig. 37d, e) Mandjelia QM S108408. Carapace 8.38 long, 7.25 wide. Abdomen 8.50 long, 5.00 wide. Total, 16.9.

I: 8.75, 3.75, 7.88, 6.63, 2.50, 29.50. II: 8.75, 3.63, 8.13, 6.38, 3.13, 30.00. III: 8.50, 3.50, 7.25, 6.88, 3.50, 29.63. IV: 10.38, 4.25, 8.88, 9.13, 4.75, 37.38. Palp: 3.75, 1.63, 2.25, –, 3.13, 10.75.

Colour faded. Carapace orange brown with broad pallid lateral bands each occupying one fifth of carapace width at that point; narrow white medial from PME to fovea. Abdomen yellow brown with white flanks; weak pattern of *Do. facetus* type discernible anteriorly with pair slender white lines breaking up into three to four paired white spots posteriorly (as in Fig. 8a); venter pallid without pattern. 10-15 long forward directed bristles overhang

PLE, fewer over PME. *Eyes.* Group width/ headwidth=0.61 through PLE, 0.54 through mid-eye group. Clypeus 0.81 long = twice PME diameter. OQ front, back, long: 50, 80, 46. MOQ front, back, long: 27, 30, 24. AME: ALE: PME: PLE, 10: 8: 15: 17. Back eye row is two well separated lines, AER with 50% overlap. Caput "shoulder" posterior to PLE. Chelicerae with two large teeth on promargin, four on retromargin. *Claws.* STC on I with 5 long teeth; ITC bare. Scopula lateral on metatarsi and tarsi I–IV. *Spines.* Pedal patella with triad. Palp: fe p1d1.1.1.2r2; pa p1d1r1; ti p2r1; ta v2. Female paratype MNHN 3.851: very similar to *Do. facetus* but abdominal pattern like *Do. flaminius* with dark flanks and pallid median band. Epigyne roughly downward arrow-shaped, with median septum only between lateral lobes in posterior quarter; internally, two concave ducts.

Distribution. Known only from New Caledonia.

Dolomedes lafoensis Berland, 1924

Dolomedes lafoensis Berland, 1924: 243, figs 192–194; male holotype. La Foa, New Caledonia, MNHP, not examined.

Diagnosis. Male with palpal tibia much longer than cymbium, RTA a low collariform ridge. Female with epigyne like that of *Do. instabilis.*

Distribution. Known only from La Foa on the western side of New Caledonia.

Remarks. The types were not found in MNHN but several aspects of the illustrated palp, viz., the long tibia and subtle RTA are very similar to that of *Dolomedes instabilis;* similarly for the epigyne. However, the median apophysis is not sufficiently well shown to confirm the absence or presence of the retrolateral process on the median apophysis. No further material from New Caledonia has been found.

NEW HEBRIDES

Dolomedes naja Berland, 1938

Dolomedes naja Berland, 1938: 179, figs 141–142; holotype male, River Jordan, Santo Island, New Hebrides, 20 Apr 1927, J.R. Baker, MNHP, not examined.

Remarks. In all of the figured characters on the male palp—the large triangular DTP, the tibia of similar length to the cymbium and the widely bifd RTA, the male of this species is indifferentiable from those of *Do. facetus.* The type was not found in MNHP and, without its examination, final confirmation of the synonymy of *Do. naja* with *Do. facetus* is not possible.

INDONESIA

Dolomedes chroesus Strand, 1911

Dolomedes chroesus Strand, 1911: 166, pl. 5, fig. 58; Davies, 1985: 102. Holotype female from forest in Wokomar, Wokam, Merauke, Indonesia, not examined.

Dolomedes chroesus: Chrysanthus, 1967: 422, figs 60, 61, female; Davies, 1985: 102.

Dolomedes facetus: Chrysanthus, 1967: 423, figs 65, 67, male misidentified.

Material. Indonesia: Aru Island: syntypes SMF 4779, 1 fem., juv. fem., not examined.

Diagnosis. Males of *Do. chroesus* differ from those of *Do. facetus* in the more slender DTP and the RTA has a shallow invagination with a longer lower lobe; the epigyne of females of *Do. chroesus* are similar to those of *Do. instabilis* but differ in the single longitudinal coil. They differ from those of *Do. facetus* in having steeply and smoothly curving lateral lobes and a large median field.

Remarks. This species is here explicitly removed from the Australian fauna. See Remarks in *Do. facetus* for explanation of crossed identifications by Chrysanthus (1967).

Distribution. Known only from Indonesia.

Tasmomedes Raven gen. nov.

Etymology. The genus name is formed from Tasmania and *Dolomedes;* the gender is masculine.

Diagnosis. Differs from *Megadolomedes* in the absence of pseudosegmented tarsi in the males and females, the absence of a PTF, the smaller RTA (Fig. 38f, g) and the less significant sexual dimorphism in size as well as the sloping profile of the carapace (Fig. 38d), as in *Dolomedes*. Most closely related to *Dolomedes*, from which it differs in the long cymbium and

conductor and small subdistal RTA. Males also differ from those of *Thaumasia* Perty, 1833 (see Silva & Carico, 2012) in that the DTP is not elongated and the embolus and fulcrum lie on the retrodistal corner of the bulb, as in *Dolomedes*.

Type species and species included: *Dolomedes eberhardarum* Strand, 1913.

Distribution. Victoria, Tasmania.

Remarks. The elevation of a genus for this species may seem equivocal but the inclusion of this species in *Dolomedes* is considered to excessively broaden the concept of the genus to make the concept unworkable.

Tasmomedes eberhardarum (Strand, 1913), new combination

(Figs 4a, 38a–I. Map 4a)

Dolomedes eberhardarum Strand, 1913: 207.

Material examined. Victoria: holotype male, "Victoria", not examined except images of palp by Weisbaden curator; 1 fem., Grampians, Mt Rosa Picnic ground, 17 Dec 1987, P. Hudson, SAMA: 1 fem., with eggs, Wilsons Promontory [39°10'S 146°20'E], northern swampland, 19 Jan 1987, A. Neboiss, MV K–13692. Tasmania: 1 fem., 1 ma., Edgar, 43°01'S, 146°21'E, button grass plain, pitfall, 18 Feb 2004, M. Driessen, QM S66980, S75790. 2 ma., Mt Anne, 42°57'S, 146°21'E, button grass plain, pitfall, 5 Mar 2004, M. Driessen, QM S75458; 1 fem., same data but 18 Feb 2004, QM S75531. 2 ma., McPartlan Pass West, 42°51'S, 146°12'E, button grass plain, pitfall, 5 Mar 2004, M. Driessen, QM S75505, S75528. McPartlan Research A, 42°51'S, 146°12'E, button grass plain, M. Driessen: 3 ma., 5 Mar 2004, QM S75512, S67892, S75516; 1 fem., 1 ma., pitfall, 18 Feb 2004, QM S67893, S67877. 1 ma., McPartlan Research B, 42°51'S, 146°12'E, button grass plain, pitfall, 5 Mar 2004, M. Driessen, QM S67872. 1 fem., Condo Nth, 42°57'S, 146°21'E, button grass plain, pitfall, 5 Mar 2004, M. Driessen, QM S75522; 1 fem., same data but 25 Feb 2004, QM S80795; 1 ma., same data but Condo NW, 5 Mar 2004, QM S77777; 2 ma., Condo 42°58'S, 146°21'E, button grass plain, pitfall, 5 Mar 2004, M. Driessen, QM S75529, S77796; 1 fem., same data but 25 Feb 2004, QM S68038; 1 ma., Harbacks Rd Sth, button grass plain, pitfall, 16 Feb 2004, M. Driessen, QM S80790. Airstrip East, 43°02'S, 146°20'E, button grass plain, pitfall, M. Driessen: 1 ma., 5 Mar 2004, QM S75507. Airstrip Rd, button grass plain, pitfall, M. Driessen: 1 fem., (site 6E), 12 Mar 2002, QM S72193; 1 ma., (site 3B), pitfall, 15 Mar 2000, QM S70390; 1 ma., 15 Mar 2000, QM S65879; 1 ma., (site 5D) 15 Mar 2000, QM S48771; 2 ma., (site 6E), 1 Apr 1999, QM S48784; 1 ma., (site 6K), 14 Mar 2001, QM S70359; 1 fem., (site 6M), 14 Mar 2001, QM S70362; 1 ma., (site 5B), 14 Mar 2001, QM S70371; fem., (sit e2J), 22 Mar 2000, QM S48795; 1 ma., (site 6F), Mar 1999, QM S48786. 2 ma., Sandfly Ck, 42°53'S, 146°22'E, button grass plain, pitfall, 5 Mar 2004, M. Driessen, QM S70022, S77784. McPartlan Pass, 42°51'S, 146°11'E, button grass plain, pitfall, M. Driessen; 1 ma., 5 Mar 2004, QM S75553; 1 ma., (site 5F), 19 Mar 2002, QM S70445; 1 ma., same data but (site 2D), QM S70446; 1 ma., same data but (site 1M), QM S70447; 1 ma., same data but (site 10M), QM S70448; 1 fem., same data but (site 8F), QM S70449; 1 ma., same data but (site 9B), QM S70450; 1 ma., QM S51333; 1 ma., same data but 12 Mar 1998, QM S48772; 2 ma., (site 5G), QM S70376; 1 ma., same data but (site 9O), QM S70273; 1 ma., same data but (site 12D), QM S70279; 2 ma., same data but (site 1M), QM S70377; 2 ma., same data but (grid 11 H), 15 Mar 2000, QM S70464; 1 ma., same data but QM S22403; 1 ma., same data but (site 1H), QM S70280; 1 ma., same data but (site 1G), QM S70281; 1 ma., same data but (site 12C), 22 Mar 2000, QM S70443. 1 ma., McPartlan Pass West, 42°51'S, 146°12'E, button grass plain, pitfall, 5 Mar 2004, M. Driessen, QM S70535; 1 ma., Wedge Inlet, 42°50'S, 146°12'E, button grass plain, pitfall, 5 Mar 2004, M. Driessen, QM S77776; 1 fem., same data but 18 Feb 2004, QM S67998; ma., Lake Pedder [42°00'S 146°10'E], 10 Mar 1972, A. Neboiss, MV K–13691; 1 ma., same data but A. Dartnall, TMAG J.

Diagnosis. Males and females differ from those of *Me. johndouglasi* in the smaller size and absence of pseudosegmented tarsi. Males differ from those of *Dolomedes* in the elongate fulcrum extending up the cymbium and the reduced form of the RTA (Fig. 38f, g). Females are unusual in the circular course of ducts in the vulva (Fig. 38i).

Description. Male QM S22403. Carapace 7.12 long, 6.24 wide. Abdomen 7.20 long, 4.16 wide. Total, 14.32.

I: 6.56; 2.80; 5.68; 5.60; 3.36; 24.00. II: 6.96; 3.20; 5.60; 5.60; 3.20; 24.56. III: 6.56; 2.56; 4.08; 4.32; 2.24; 19.76. IV: 7.76; 3.20; 0.56; 7.20; 2.64; 21.36. Palp: 3.20; 1.28; 1.20; 3.76; 9.44.

Colour. Carapace dark red brown with wide brown edges and narrow submarginal pallid band, no medial line. Abdomen dark with light flanks for one-third irregular pallid ostiate region; venter well defined with irregular pallid lines (as in Fig. 38c, d). *Eyes.* Group width/ headwidth=0.70 through PLE, 0.53 through

mid-eye group. OQ front, back, long: 34, 56, 44. MOQ front, back, long: 19, 29, 17. AME: ALE: PME: PLE, 8: 7: 11: 10. PER just anterior to caput shoulder. AER with 40% overlap; PER two well separated lines *ca.* 0.5 of PME diameter. Pedal patella d1 (basal) p1r1. Chelicerae: 3p, 4r. Femur IV unmodified. STC with *ca.* 8 teeth; ITC bare. *Palp* (Fig. 38f, g). Tibia very short, similar in size to patella, RTA a low ridge or cone mid-laterally on retroventral edge, proventral edge with broad "shelf". Cymbium concavity extends for length; retroventrally, VTA with large lobe paddle-shaped; fulcrum and conductor very long, cymbium groove very long; DTP banana-shaped, widest at mid-length, with ends irregular; MA anvil-like, apically with flared groove.

Female QM S68038. Carapace 7.28 long, 6.16 wide. Abdomen 10.00 long, 5.60 wide. Total, 17.28.

I: 6.16; 3.12; 5.04; 4.40; 2.40; 21.12. II: 6.00; 3.20; 4.80; 4.32; 2.24; 20.56. III: 5.28; 2.80; 2.88; 4.72; 2.32; 18.00. IV: 6.96; 3.04; 5.84; 6.40; 2.56; 24.80. Palp: 3.04; 1.52; 1.60; 2.48; 8.64.

Carapace dark red, broad brown edges, narrow pale submarginal band, lighter medial band around fovea and on caput. Abdomen with large dark ostiate area with pallid area around it, dark upper edge with mottling laterally; dark venter with two pairs of pallid parentheses-shaped areas centrally. *Eyes.* Group width/headwidth=0.67 through PLE, 0.50 through mid-eye group. OQ front, back, long: 39, 60, 41. MOQ front, back, long: 20, 29, 25. AME: ALE: PME: PLE, 8: 9: 12: 12. PER cut curve of caput shoulder. AER with 20–30% overlap; PER two well separated lines *ca.*1 PME diameter apart. *Spines.* Palp: fe p1d1.1.1.2r1; pa p1d.1.1; ti p2d1.1; ta pv1rv1.1. STC with 7 teeth; ITC bare. Scopula on tarsi I–IV. Epigyne (Fig. 38h, i). Lateral ridges smoothly curving with septum in distal quarter; internally, ducts follow circular path.

Distribution and Habitat. Tasmania, Victoria. In Tasmania, the spiders were found in button grass moorland which does not have flowing water.

Remarks. Males of *T. eberhardarum* have a similar palp to those of *Megadolomedes* in the elongate fulcrum (Fig. 38f, g) extending up the length of the cymbium. However, unlike both species of *Megadolomedes*, they lack the pseudosegmented tarsi and, apart from the palp, are similar to other very "standard" *Dolomedes* species treated here.

Megadolomedes Davies & Raven, 1980

Megadolomedes Davies & Raven, 1980: 135.

Type species. *Dolomedes australianus* L. Koch, 1865, by original designation.

Included species. *Megadolomedes australianus* (L. Koch, 1865); *Megadolomedes johndouglasi* sp. nov.; *Megadolomedes trux* (Lamb, 1911); *Megadolomedes nord* sp. nov.

Diagnosis. Males and females differ from those of all other Australian pisaurids, except *Hygropoda*, in the long slender, pseudosegmented tarsi (e.g. Fig. 7e). Males and females differ from those of *Hygropoda* in the small ALE (Fig. 42a) in a distinctly recurved line (vs large and straight, Fig. 79a) and the small simple conical RTA (Figs 40b, 41b, 43a); females differ in the very large size and the epigyne being very wide rather than narrow.

Description. Males and females with pseudosegmented tarsi; sexual dimorphism notable (*Me. australianus, Me. trux*) or minor (*Me. johndouglasi*). PTF present. Carapace in lateral view flat, sloping down very little to eye region (as in Fig. 5f). Eyes of PER larger than those of AER; AER about 0.6–0.70 of width of PER. Creekside diurnal and nocturnal spiders hunting freely beside creeks usually with at least first pair of legs in water.

Distribution. Eastern Australia from Queensland to Tasmania.

Remarks. Davies and Raven (1980) diagnosed the genus based on the males of the sole species known, *Megadolomedes australianus*, and noted the strong sexual dimorphism. Those males were taken from Queensland, well north of the type locality near Sydney, New South Wales. A male from the Sydney region is not conspecific with that from Queensland figured and listed by Davies and Raven (1980) which

are here considered to be the newly restored *Megadolomedes trux*. However, in the genus, although all species have similar palps (where known) and epigynes, the sexual dimorphism in size is not so strong in *Me. johndouglasi* as in two of the northern species.

History. Davies and Raven (1980) revised the *Dolomedes australianus* group and concluded that both *Dolomedes cervinus* L. Koch, 1876 and *Dolomedes trux* Lamb, 1911 were conspecific with it, synonymised the species and diagnosed a new genus.

KEY TO SPECIES

Males (Males of *Me. nord* sp. nov. unknown)

1. Cymbium very long, embolus extends as to tip of cymbium (Figs 40a, 41a; New South Wales, Queensland) 2
– Cymbium slightly elongate, embolus not reaching cymbial top (Fig. 43a; Tasmania, Victoria) ..... *Me. johndouglasi* sp. nov.

2. Large spine at base of embolus (Fig. 41b) ..... *Me. trux*
– No spine at base of embolus (Fig. 40a, b) ..... *Me. australianus*

Females

1. Epigyne clearly longer than wide (Figs 42d, 43c) 2
– Epigyne as wide as long or wider (Figs 40d, 42b) 3

2. (1). Epigyne with spermathecal coils fused (Fig. 43d; Tasmania, Victoria) ..... *Me. johndouglasi* sp. nov.
– Epigyne with three separate spermathecal coils (Fig. 42e; Cape York, Queensland) ..... *Me. nord* sp. nov.

3. (1). Spermathecae confined to posterior third of epigyne (Fig. 40d; central coastal New South Wales) ..... *Me. australianus*
– Spermathecae extend for at least half of epigyne (Fig. 42c; Queensland to northern coastal New South Wales) ..... *Me. trux*

Megadolomedes australianus (L. Koch, 1865)

(Fig. 40a–d. Map 4b)

Dolomedes australianus L. Koch, 1865: 863; L. Koch, 1876: 873, pl. 75, fig. 2.

Dolomedes cervinus L. Koch, 1876: 872, pl. 75, fig. 1. Holotype whereabouts unknown, juvenile, Nepean River, New South Wales; considered lost from ZMH, see Davies (1985).

Material examined. Type. New South Wales: holotype (*Dolomedes australianus)* juvenile male, ZMH 302, examined.

Other Material examined. New South Wales: 1 fem., Budderoo National Park, Minnamurra Rainforest Centre, 34°38'S 150°44'E, on boulder in narrow gorge at foot of waterfall, R. Oberprieler, A. Zwick, ANIC 42-002260; 1 ma., Double Dumps Fire Trail, 700 m off Daisy Patch Rd, Enfield State Forest, 163AS., 31°20'50"S 151°54'E, 1080 m, 4 Feb–9 Apr 1993, pitfall, G.A. Cassis, M.R. Gray, AM KS39496; 1 fem., Colo River, 8 km north of Upper Colo, 33°24'S 150°40'E, 14 Mar 1997, L. Voigt, AM KS53192; 1 fem., Bulliac, AM K34553.

Diagnosis. Males differ from those of *Me. trux* and *Me. johndouglasi* sp. nov. in the short barrel-shaped palpal tibia and the DTP is broad and thumb-like. Females differ from those of *Me. johndouglasi* sp. nov. in the different abdominal pattern (see Davies & Raven 1980, figs 8–12), the relatively broader epigyne and the thread-like overlying spermathecal coils. Females differ from those of *Me. trux* in that the spermathecae are aligned transversely and thus occupy relatively less of the epigyne (Fig. 40d).

Description. Male AM KS39496. Carapace 6.00 long, 4.96 wide. Abdomen mashed.

I: 6.48, 2.64, 6.24, 6.48, 3.60, 25.44. II: 6.48, 2.72, 6.24, 6.16, 3.44, 25.04. III: , 6.16, 2.56, 5.04, 5.52, 2.80, 22.08. IV: 6.64, 2.80, 6.32, 6.80, 4.80, 27.36. Palp: 3.20, 1.20, 1.20, 4.72, 10.32.

Eyes. Eye group width/headwidth= 0.64 through PLE, 0.53 through PME. Eye group front: back: long, 30: 44: 29. MOQ front: back: long, 15; 24: 20. AME: ALE: PME:PLE, 6: 5: 10: 10. PER cuts posterior of shoulder. Back eye row in just two lines. From above, AER overlap 30%. Chelicerae with 2 teeth on promargin, 4 separated on retromargin. *Claws.* STC I with 8–10 teeth. *Spines.* Palp: fe p1d1.1.1.2r1; pa 0; ti p1d1. Palp. Conductor large, racket-shaped,

distally sinuous beside embolus. Embolus base roughly conical with no processes or spines; cymbium highly twisted; median apophysis flared; DTP roughly right-angled; embolus extends to end of cymbium. RTA pointed, apically bent. VTA tripartite with broad distal lobe.

Female ANIC, Budderoo National Park. Carapace 13.68 long, 12.87 wide. Abdomen 18.22 long, 12.15 wide.

I: 20.60, 7.03, 19.68, 17.22, 14.17, 78.70. II: 21.39, 7.59, 18.70, 17.57, 14.17, 79.42. III: 19.28, 7.58, 16.45, 16.03, 11.83, 71.17. IV: 22.01, 7.31, 19.36, 23.13, 12.83, 84.64. Palp: 4.67, 2.83, 4.17, 5.33, 17.00.

Eyes. Eye group width/headwidth= 0.54 through PLE, 0.43 through PME. Eye Group front: back: long, 59: 97: 52. MOQ front: back: long, 20: 43: 32. AME: ALE: PME:PLE, 12:7:14:15. PER cuts through middle of shoulder. Back eye row in two lines separated by half of ALE. From above, AER overlap 12%. Chelicerae with two teeth on promargin, 4 separated on retromargin. White hair on distal patella and basal tibia of palp. *Claws*. Palp with 5 teeth; 5–7 on STC I. *Spines*. Patellae: p1d1r1. Palp: fe p1d1.1.1.2r1; pa p1d2; ti p2d2; ta p1r1v2. I: fe p5d3r5; pa p1d1r1; ti p1d3r1v2.2.2; me p2r2v2.2.2. Epigyne with broad, smoothly curving lateral lobes and median field in distal third; vulva with large posterior lobe and successively smaller anterior lobes overlain with three loops of filamentous ducts.

Distribution. From just north of Sydney at the Nepean River south through at least to Wooloongong, New South Wales.

Megadolomedes trux (Lamb, 1911) new comb.

(Figs 1c, h, 3b, c, 39a–c, 40a–c, 52a–c. Map 4b)

Dolomedes trux Lamb, 1911: 173, fig. 4; Rainbow, 1912: 210, figs 1–3; Davies & Gallon, 1986: 235. First synonymised with *Me. australianus* by Davies & Raven (1980), here rejected.

Megadolomedes australianus: Davies & Raven, 1980: 136, figs 1–12, plate 1A–D, male and female misidentified.

Material examined. Type: Queensland: holotype, penult. female, Brisbane, QM G55, examined.

Other Material Examined. Queensland: 1 fem., Unanderra, 12 May 2005, per AQIS, QM S69850; 4 fem., 1 penult. ma., Conondale Ra., 26°45′S, 152°37′E, rainforest, 1974, R.J. Raven, QM S13487; fem., near Cairns [17°00′S 145°50′E], May 1957, MV K–13688; 1 fem., The Gap, Brisbane, 27°27′S, 152°57′E, 29 Nov 1972, R. McKay, QM S13495; 1 fem., Warro SF, 24°33′S, 151°44′E, 3 Jun 1974, P. Filewood, QM S13488; 1 fem., Mt Windsor Tableland, base camp, 16°12′S, 145°05′E, camp site, 26 Dec 1980, Australian New Zealand Schools Expedition Society expedition, QM S13483; 2 fem., Proserpine, Lethe Brook crossing, site XY20, 20°24′S, 148°31′E, rainforest, beating, 15 Mar 2008, R.J. Raven, QM S86873; 1 ma., Toomba Homestead site, 19°58′S, 145°34′E, basalt ridge with *Brachychiton*, night collection, 16 Dec 2006, R.J. Raven, QM S79215; 1 fem., Davies Ck, 16°55′S, 145°32′E, 30 Mar 1975, N. Clyde Coleman, QM S235; 1 fem., Mt Molloy, 16°41′S, 145°20′E, Sept 1969, F. Little, QM S236; 2 fem., Booloumba Ck, Conondale Ra., 26°39′S, 152°39′E, rainforest, Mar 1973, R.J. Raven, QM S237; 1 fem., Kroombit Tops, Lower Kroombit Ck, 24°25′S, 151°03′E, 15 Dec 1983, V. Davies, J. Gallon, G. Thompson, P. Lawless, QM S13489; 1 fem., Home Rule, Wallaby Ck, 15°44′S, 145°15′E, rainforest, 18 Nov 1974, D. Joffe, V. Davies, QM S233; 2 fem., Home Rule, Wallaby Ck, 15°44′S, 145°18′E, rainforest, 19 Nov 1974, J. Covacevich, D. Joffe, V.E. Davies, QM S234; 1 fem., Kroombit crossing, Kroombit Tops, Site 15, 24°22′S, 151°01′E, 15 Dec 1983, V. Davies, J. Gallon, G. Thompson, P. Lawless, QM S13479; 1 fem., Shiptons Flat, 15°48′S, 145°15′E, rainforest, 1975, L. Roberts, QM S13481; 1 fem., Mt Coot-tha, Brisbane, 27°29′S, 152°57′E, 12 Jul 1988, R.J. Raven, QM S13515; 1 ma., 1 fem., Gayundah Ck, Hinchinbrook Is., 16.09 km N of track, 18°22′S, 146°13′E, rainforest, 7–14 Nov 1984, V. Davies, J. Gallon, QM S13484; 1 ma. 3, Cedar Ck, near Samford, 27°22′S, 152°53′E, rainforest, 21 Dec 1978, R. Raven, V. Davies, QM S13486; 1 ma., Cedar Ck Falls, via Samford, 27°22′S, 152°53′E, rainforest, 5 Feb 1986, R.J. Raven, J. Gallon, QM S13519; 1 fem., Mt Moffatt NP, Top Moffatt Camp, 25°01′S, 147°57′E, SC, 13–15 Dec 1987, J. Gallon, QM S14504; 2 fem., Blackdown Tableland, 23°48′S, 149°08′E, open forest, 1 Feb 1981, R.J. Raven, QM S13490; 1 ma., 1 fem., Home Rule, Wallaby Ck, 15°44′S, 145°18′E, rainforest, 19 Nov 1974, J.Covacevich, D. Joffe, V.E. Davies, QM S194; 1 ma., Cedar Ck, Mt Glorious, 27°21′S, 152°46′E, rainforest, 16 Nov 1973, R.J. Raven, QM S230; 2 ma., Home Rule, Wallaby Ck, 15°44′S, 145°18′E, rainforest, 19 Nov 1974, J. Covacevich, D. Joffe, V.E. Davies, QM S231; 1 fem., Kondalilla NP, 26°40′S, 152°52′E, rainforest, 10 Dec 1973, R.J. Raven, QM S238; 1 fem., Goodna reach, Brisbane R, 27°35′S, 152°54′E, 13 May 1975, R. Monroe, QM S239; 1 fem., Beerburrum, 26°58′S, 152°58′E, 29 Nov 1951, G.J. Male, QM S240; 1 fem., Little Yabba Ck, 26°37′S, 152°41′E, rainforest, 25–26 Jan 1975, G. May, QM S241; 1 fem., Kilcoy Ck, E branch, 26°42′S, 152°34′E, 15 Nov 1978, K. McDonald, QM S242; 3 fem., Mt Tamborine, 27°56′S, 153°12′E, rainforest, 12 Nov 1979, QM S13478; 1 fem., Booloumba Ck, Conondale Ra., 26°39′S,

152°39′E, rainforest, 8 Aug 1986, R. Raven, J. Gallon, QM S13511; 1 fem., Blackall Ra., 26°34′S, 152°52′E, C.J. Wild, QM S13480; 1 fem., Cooloola, 26°12′S, 153°03′E, 13 Jul 1973, R.J. Raven, QM S13513; 1 fem., Mt Glorious, 27°20′S, 152°46′E, rainforest, 19 Jul 1974, R.J. Raven, QM S13514; 1 fem., Cape Tribulation, 16°05′S, 145°26′E, Apr 1990, R.J. Raven, QM S20428; 1 fem., Mt Coot-tha, J.C. Slaughter Falls, 27°30′S, 152°55′E, 12 Dec 1989, R. Raven, J. Gallon, QM S12538; 1 fem., Mt Spurgeon, 3 km S, 16°27′S, 145°11′E, sclerophyll, 19–23 Nov 1997, G. Monteith, D. Cook, C. Burwell, QM S41847; 1 fem., 1 penult. ma., Crows Nest, 27°16′S, 152°03′E, G. May, QM S13517; 1 fem,. 1 penult. ma., Kilcoy Ck, E branch, 26°45′S, 152°34′E, 15 Nov 1978, K. McDonald, QM S13512; 1 fem., Conondale Ra., 26°45′S, 152°37′E, rainforest, 23 Feb 1975, G. Maywold, G. Czechura, QM S13508; 1 ma., Mt Coot-tha, J.C. Slaughter Falls, 27°30′S, 152°55′E, 12 Dec 1989, R. Raven, J. Gallon, QM S15536; 1 ma., Stone Ck. (Hasenpusch), 17°28′S, 146°01′E, 7 Dec 1995, G. Monteith, G. Thompson, D. Cook, QM S37961; 1 ma., Mt Coot-tha, J.C. Slaughter Falls, 27°30′S, 152°55′E, 12 Dec 1989, R. Raven, J. Gallon, QM S15537; 1 fem., Henrietta Ck, 18 km SW Millaa Millaa, 17°36′S, 145°45′E, 16 Apr 1997, C. Burwell, G. Monteith, J. Wright, QM S40143; 1 ma., Mt Coot-tha, J.C. Slaughter Falls, 27°30′S, 152°55′E, 12 Dec 1989, R. Raven, J. Gallon, QM S15535. New South Wales: 1 fem., Gordon, 8 Dec 1982, AM KS10601; 1 fem., Richmond Ra., 28°20′S, 152°55′E, rainforest, 14 Sep 1974, R.J. Raven, QM S232; 2 fem., Cudgen, 28°16′S, 153°33′E, 20–21 Nov 1978, R. Raven, H. Heatwole, G. Czechura, QM S13503; 1 fem., Richmond Ra., 28°20′S, 152°55′E, open forest, 16 Apr 1976, R.J. Raven, QM S13491; 1 fem., Whian Whian SF, 28°41′S, 153°19′E, rainforest, 9–12 Sep 1976, R.J. Raven, QM S13492.

Juveniles with only locality, coordinates, and registration number. Queensland: Burnett Ck, 25°08′S, 152°04′E, QM S13516; Booloumba Ck, Conondale Ra., 26°39′S, 152°39′E, QM S67780; North Stradbroke Is., 1.6 km N Dunwich, 27°30′S, 153°24′E, QM S13494; Kilcoy Ck, E branch, 26°45′S, 152°34′E, QM S13496; Teviot Brook, Boonah, 27°57′S, 152°33′E, QM S13499; Forest Glen, 26°42′S, 152°59′E, QM S13500; Mudgeeraba, 28°05′S, 153°22′E, QM S13501; Kilcoy Ck, 26°45′S, 152°34′E, QM S13493; Blackall Ra., 26°34′S, 152°52′E, QM W2146; Home Rule, 15°44′S, 145°18′E, QM S13482; Majors Mt, 17°38′S, 145°32′E, QM S13485; Spear Ck, 16°42′S, 145°24′E, QM S13520; Eungella NP, 21°10′S, 148°30′E, QM S13504; Enoggera, Brisbane, 27°26′S, 152°57′E, QM S13518; Bloomfield, 16°04′S, 145°09′E, QM S13507; Finch Hatton NP, Finch Hatton Gorge, 21°04′S, 148°38′E, QM S13505; Laidley Ck, 27°31′S, 152°25′E, QM S13497; Conondale Ra., 26°45′S, 152°37′E, QM S13510; Kilcoy Ck, 26°47′S, 152°43′E, QM S13509; Kroombit Tops, Callide Ck, Site 16, 24°25′S, 151°03′E, QM S13498; Gayundah Ck, Hinchinbrook Is., 18°22′S, 146°13′E, QM S13506; Cape Tribulation, 16°05′S, 145°26′E, QM S20476.

Diagnosis. Males differ from those of *Me. johndouglasi* sp. nov. in the short barrel-shaped palpal tibia and the broad and thumb-like DTP. Females differ from those of *Me. johndouglasi* sp. nov. in the different abdominal pattern (see Davies & Raven 1980, figs 8–12), the relatively broader epigyne and the thread-like overlying spermathecal coils.

Description. *Male* QM S79215. Carapace 3.76 long, 3.36 wide. Abdomen 3.84 long, 1.84 wide. Total, 7.60.

I: 5.60, 0.96, 5.44, 5.44, 3.20, 20.64. II: 5.36, 1.68, 5.20, 4.88, 3.52, 20.64. III: 4.40, 1.36, 3.92, 4.08, 2.80, 16.56. IV: 5.92, 1.68, 4.64, 5.52, 4.24, 22.00. Palp: 1.20, 0.40, 0.32, 1.60, 3.52.

Eyes. Eye group width/headwidth= 0.73 through PLE, 0.55 through PME. Eye Group front: back: long, 47: 75: 40. MOQ front: back: long, 25: 38: 20. AME: ALE: PME:PLE, 10: 9: 13: 15. Back eye row in two lines well separated by half of ALE. From above, AER overlap 12%. PLE on large tubercles, higher posteriorly. Clypeus = 1.80 mm. Chelicerae with two teeth on promargin, 4 separated on retromargin. *Claws.* 8 teeth on STC I. *Spines.* Patellae: p1d1r1. Palp: fe p1d1.1.1.2r1; pa d1; ti 0.

Female QM S13478. Carapace 13.78 long, 11.65 wide. Abdomen 16.27 long, 9.46 wide. Total, 30.0.

I: 19.84, 7.51, 18.73, 17.01, 15.63, 78.72. II: 19.63, 7.8, 18.32, 17.81, 15.03, 78.59. III: 18.57, 6.65, 15.60, 15.93, 12.54, 69.29. IV: 21.95, 7.03, 18.76, 20.98, 16.04, 84.76. Palp: 7.00, 3.00, 4.17, 7.50, 21.67.

Eyes. Eye group width/headwidth= 0.55 through PLE, 0.38 through PME. Eye Group front: back: long, 55: 91: 50. MOQ front: back: long, 28: 41: 32. AME: ALE: PME: PLE, 12:8:16:15. PER cuts through middle of shoulder. Back eye row in two lines separated by half of ALE. From above, AER overlap 15%. PLE on large tubercles, higher posteriorly. Clypeus= 1.80 mm. Chelicerae with two teeth on promargin, 4 separated on retromargin. *Claws.* Palp with 6 teeth; 8 on STC I. Scopula absent. *Spines.* Patellae: p1d1r1. Palp: fe p1d1.1.1.2r1; pa

p1d2r1; ti p2d2; ta p1r1v2. I: fe p5d3r5; pa p1d1r1; ti p1.2d1r2v2.2.2; me p2r2v2.2.3. Epigyne with broad, smoothly curving lateral lobes and median field in distal third; vulva with large posterior lobe and successively smaller anterior lobes overlain with three loops of filamentous ducts.

Distribution. East of the Great Dividing Range, at least from northern New South Wales, possibly further south, to Cooktown, north Queensland. Females from Gordon, central New South Wales, are unequivocally those of *Me. trux* and thus a very narrow zone south of which *Me. australianus* occurs.

Megadolomedes johndouglasi sp. nov.
(Figs 39d, 43a–d. Map 4c)

Dolomedes australianus: Hickman, 1967: 82, figs 144–146. Misidentification.

Etymology. Named in honour of Mr John Douglas, Citizen scientist and Honorary at the Queen Victoria Museum and Art Gallery, Launceston, who persistently refused to allow RJR to ignore the significance of the larger male of which he had only photos.

Material examined. Tasmania: holotype, male, Forth, Forth River, P. Zwick, April 1972, QM S28796; paratype (allotype), TMAG J2851, 1 fem. with egg sac, Tunnack, 28 Dec 1988, Mrs S. Irvine; fem. Gowen Brae, beside stream, R. Raven, 24 Feb 2014; juv. fem., Saxon Ck, 10 km N Frankfort [41°16′S 146°42′E], 19 Nov 1972, A. Neboiss, MV K-13674; 1 fem., Trowutta Natural Arch, Cave twilight zone, 41°02′S 145°05′E, 21 Jan 1981, N. Poulter, AM KS8609. Victoria: 1 fem. with egg sac, Gibbo R., [36°50′S 147°40′E], 325 km N of Benambra, 25 Feb 1993, G. Milledge, MV K-13669; fem., Thompson River Gorge, Gippsland [38°00′S 146°40′E], 15 Dec 1964, MV K-13670; fem., Porepunkah [36°40′S 146°50′E], 27 Jan 1957, A. Neboiss, MV K-13671; fem., Dartmouth Survey, Mitta Mitta R./Toke Ck [36°30′S 147°20′E], 30 Mar 1974, MV K-13672; fem., no data, MV K13673; 1 fem., Bemm R, 37°46′S, 148°58′E, creek margin, 16–28 Nov ?1993, V. Salanitri, QM S28789; 1 juv. probable, Upper Tumut Gorge, Snowy Mtns, 35°20′S, 148°14′E, 28 Feb 1957, I.G. Filmer, QM S13502.

Diagnosis. Males differ from those of *Me. australianus* in the long cylindrical palpal tibia, the longer, curved DTP, the fulcrum extends only to the subapical cymbium, and the relatively larger size of the spider. Females differ from those of *Me. australianus* in the different abdominal pattern (Fig. 39d), the relatively narrower epigyne (Fig. 43c) and fewer spermathecal coils (Fig. 43d).

Description Holotype male QM S28796. Carapace 6.80 long, 5.84 wide. Abdomen 4.80 long, 4.00 wide. Total, 11.6.

I: 8.16; 2.80; 7.36; 8.80; 4.40; 31.52. II: 8.64; 3.12; 7.76; 8.32; 6.40; 34.24. III: 7.36; 2.96; 6.88; 6.80; 4.48; 28.48. IV: 9.44; 3.92; 7.68; 9.20; 6.16; 36.40. Palp: 3.92; 1.28; 1.60; 3.04; 9.84.

Colour. Carapace and abdomen faded entirely yellow, without pattern. *Eyes.* Group width/headwidth=0.71 through PLE, 0.50 through mid-eye group. OQ front, back, long: 33, 55, 29. MOQ front, back, long: 11, 25, 16. AME: ALE: PME: PLE, 6: 6: 9: 10. PER cuts through mid-curve of caput shoulder. AER with 30% overlap; PER in two well lines separated by *ca.* 0.6 of PME diameter. Chelicerae 3p, 4r; fang broad for most of its length. Tarsi pseudosegmented, strongly curved; tarsal measurements about 6% shorter than actual. *Spines.* Palp: fe p1d1.1.1.2; pa p1; ti p1. Palp: RTA a simple conical subdistal spine set retrodorsally.

Allotype Female TMAG J2851. Carapace 9.67 long, 8.67 wide. Abdomen 10.50 long, 7.17 wide. Total, 20.2.

I: 11.50; 4.83; 10.83; 11.50; 8.17; 46.83. II: 11.83; 5.00; 11.33; 10.33; 8.00; 46.50. III: 10.83; 4.17; 9.17; 10.17; 7.17; 41.50. IV: 13.50; 5.00; 11.67; 13.00; 9.00; 52.17. Palp: 4.33; 2.00; 2.33; 4.33; 13.00.

Carapace dark brown, edge to posterior caput light brown with broad pallid submarginal band to clypeus; two slender ovoid pallid spots anterior to fovea; pile of short black hairs darken effect. Abdomen dorsally dark brown with two full length bands of white hairs along edge partially forming 3 chevrons posteriorly; narrower band around edge of ostiate area; legs annulate; laterally abdomen dark, paler venter with pair of lines of sclerotised spots. Carapace profile flat. *Eyes.* Clypeus 1.00 mm to AME. Group width/headwidth=0.53 through PLE, 0.28 through mid-eye group. OQ front, back, long: 45, 74, 44. MOQ front, back, long: 21, 33, 25. AME: ALE: PME: PLE, 8: 8: 14: 13. PER cuts through mid-curve of caput shoulder. AER almost without overlap; PER in two well

separated lines by 0.6 of PME. Chelicerae 4r, 2p. STC 7–8; ITC, 0. Epigyne with lateral lobes forming heart-shape, edges anteriorly and posteriorly, convergent with slight discontinuity at distal limit of the median field; median field with subtle trianguloid corners anteriorly. Vulva with CD curving to dorsum quickly widening and coiling once (Fig. 43d).

Distribution. Tasmania, Victoria.

Remarks. *Me. johndouglasi* is by far the largest pisaurid in Tasmania and Victoria.

Megadolomedes nord sp. nov.
(Fig. 42d, e. Map 4c)

Etymology. The species epithet is a noun in apposition for the French word for north, nord.

Material examined. Queensland: holotype female, Iron Range, 12°45'S 143°19'E, 24–30 June 1976, R. Raven, V. Davies, QM S67749; paratypes, females, same data as holotype, QM S108410.

Diagnosis. Females differ from those of *Me. trux* in the relatively long epigyne (Fig. 42d) and the similar or anteriorly enlarging lobes of spermathecae are directly more distally (Fig. 42e).

Description. Holotype female QM S67749. Carapace 8.83 long, 8.00 wide. Abdomen 10.33 long, 6.17 wide. Total, 19.2.

I: 13.00, 4.67, 11.33, 12.00, 9.33, 50.33. II: 13.17, 5.00, 13.67, 13.67, 8.83, 54.33. III: 12.00, 4.17, 10.17, 10.17, 7.67, 44.17. IV: 14.17, 4.67, 12.33, 14.33, 10.33, 55.83. Palp: 4.00, 1.83, 2.50, 3.83, 12.17.

Eyes. Eye group width/headwidth= 0.48 through PLE, 0.38 through PME. Eye Group front: back: long, 42: 66: 40. MOQ front: back: long, 23: 35: 25. AME: ALE: PME: PLE, 10: 6: 15: 13. From above, AER overlap 30%. Clypeus=0.63 mm. Chelicerae with two teeth on promargin, 4 separated on retromargin. *Claws.* 6 teeth on STC I. Scopula on metatarsi I, II and in two narrow lateral bands on III, IV. *Spines.* Patellae: p1d1r1. Palp: fe p1d1.1.1.2r1; pa p1d2r1; ti p2d2; ta p1r1v2. I: fe p5d3r5; pa p1d1r1; ti p2d1.1r2v2.2.2; me p3r5v2.2.3. II, III: fe p5d3r5; pa p1d1r1; ti p2d2r2v2.2.2; me p3r5v2.2.3. IV: fe p5d3r3, rest as I. Epigyne with broad, smoothly curving lateral lobes, narrowing slightly at median field in distal third; vulva with small posterior lobe and successively larger anterior lobes without filamentous ducts.

Distribution. Cape York, Iron Range, Queensland.

Ornodolomedes, gen. nov.

Etymology. The genus name is formed from ornate and *Dolomedes;* the gender is masculine.

Type species. *Ornodolomedes benrevelli* sp. nov.

Genus Common name. Rainforest Sprites

Diagnosis. Males and females differ from those of most other Australian pisaurids by the long overlapping spines on the ventral tibiae and metatarsi (Fig. 7f), from *Hygropoda* in the absence of pseudosegmented (curved) tarsi and from *Mangromedes,* gen. nov., in males having a small distal RTA and females having the epigyne of normal width, not with "wings". Males and females are readily distinguished from those of *Dolomedes* by the ornate pattern on the carapace and abdomen.

Diagnostic description. Males and females of similar size. Carapace flat in lateral view or with medial saddle rising to eye region (Figs 5e, f, 50c). With median dark inverted V on inner diagonals of cheliceral face (e.g. Fig. 50d). Eyes of PER larger than those of AER; AER about 0.7 of width of PER (Figs 54e, 56c, d). MOQ subvertical; thus MOQ length from above small. Abdomen laterally dark with well defined pallid venter. PTF present. Tarsi not pseudosegmented. Scopula absent. Palpal femur dorsal spines, either 1.2 or 1.1.2 (most species), rarely 1.1.1.2. Three (tibiae) and two (metatarsi) very long pairs of ventral spines (each plus 1 short distal pair) on I, II overlap and alone span length of article. *ca.* 6 teeth on STC. Male cymbium shorter (*Ornodolomedes gorenpul* sp. nov.) than or longer than palpal tibia (all other species). Arboreal nocturnal spiders hunting freely on leaves and bark in closed forests.

Included species. *O. benrevelli* sp. nov., *O. gorenpul* sp. nov., *O. mickfanningi* sp. nov., *O. marshi* sp. nov., *O. nebulosus* sp. nov., *O. nicholsoni* sp. nov., *O. southcotti* sp. nov., *O. xypee* sp. nov., *O. yalangi* sp. nov.

Distribution and Habitat. Found in rainforest, vine thickets and in riverine areas of closed eucalypt forest in Queensland, New South Wales, Victoria, South Australia and Western Australia.

Remarks. The genus common name, Rainforest Sprites, was conferred by Jude McAuley as part of the launch of the World Science Festival Brisbane at the Queensland Museum in March 2017.

KEY TO *ORNODOLOMEDES* SPECIES

Males (males of *O. xypee* sp. nov., unknown)

1. Palpal tiba long, only slightly shorter than cymbium (cymbium =1.10–1.40x tibia, e.g. Fig. 63j) 2
— Palpal tiba short, much shorter than cymbium (cymbium =1.80–2.2x tibia, e.g. Fig. 63a) 6

2. DTP apically blunt (Fig. 46a) 3
— DTP apical conical or truncated (Fig. 57a) . . 5

3. RTA in lateral view a broad ridge with 2–3 small points (Fig. 63e, i) 4
— RTA in lateral view narrow rectanguloid (Fig. 46b) . . . . . O. *benrevelli*

4. RTA trianguloid, apically bifid (Fig. 63e) . . . . . *O. yalangi*
— RTA rectanguloid (Fig. 63i) . . . . *O. staricki*

5. RTA in lateral view small, thumblike (Figs 51b, 52c) . . . . . *O. mickfanningi*
— RTA in lateral view a broad keel (Fig. 57a, b) . . . . . *O. southcotti*

6. RTA in lateral view subtle (Fig. 49b) . . . *O. gorenpul*
— RTA in lateral view distinct (Figs 53c, 59d, 61d) 7

7. RTA in ventral view a strongly procurved hook (Fig. 53b) . . . . . *O. nebulosus*
— RTA in ventral view a conical spine (Figs 59b, 61b) 8

8. Palpal tibia longer than cymbium (Fig. 59b) . . . . . *O. nicholsoni*
— Palpal tibia clearly shorter than cymbium (Fig. 61d) . . . . . *O. marshi*

Females (females of *O. southcotti, O. staricki,* and *O. marshi* and *O. nebulosus* unknown)

1. Epigyne with long median field occupying >60% of length (Figs 46c, 51c, 59e) 2
— Epigyne not as above 4

2. Overall shape of epigyne clearly wider than long (Fig. 46c) . . . . . *O. benrevelli*
— Overall shape of epigyne as wide as long or longer (Figs 51c, 59e) 3

3. Epigyne trianguloid (Fig. 59e) *O. nicholsoni*
— Epigyne broadly pear-shaped (Fig. 51c) . . . . . *O. mickfanningi*

4. Epigyne with narrow anterior median scape, median field arrow head shaped (pointed posteriorly, e.g. Fig. 60b) 5
— Epigyne with broad anterior median scape and median field indistinct but with posterior median scape (Fig. 49c). *O. gorenpul*

5. Epigyne externally with dark slender sigmoidal duct (Fig. 60b) . . . . . *O. xypee*
— Epigyne externally with large folded ducts appearing tear-shaped (Fig. 61d) *O. nebulosus*

Ornodolomedes benrevelli sp. nov.
(Figs 44a–c, 45, 46a–d, 47a–c. Map 4d)

Etymology. The species epithet is honour of the collector and photographer, Mr Ben Revell, in testament to his efforts as a "Citizen Scientist" for collecting a species that had remained so long undiscovered so close to Brisbane, despite day and night arachnological expeditions to the area.

Common Name. Masked Wood sprite.

Material examined. Queensland: holotype male, Mt Glorious, rainforest, 27.32579°S, 152.76199°E, B. Revell, May 2016, QM S104920; 2 female paratypes, same data, QM S104916.

Diagnosis. The male palp is very similar to that of *O. mickfanningi* sp. nov., in that the RTA is quite long (Figs 46a, 47a) but differs in that the RTA is more basal, the cymbium is only slightly longer than the tibia and the DTP is broader. Compared to that of *O. mickfanningi* sp. nov., the epigyne is clearly longer than wide and the spermathecal ducts more slender, widely spaced

and diagonal. Males and females are easily recognised from other pisaurids by the distinctive bold brown, black and pallid markings on the carapace and abdomen (Figs 44a–c, 45).

Description. Holotype male QM S104920. Carapace 3.72 long, 3.28 wide. Abdomen 3.48, 2.32 wide. Total, 7.20.

I: 4.88; 1.60; 4.40; 4.56; 2.64; 18.08. II: 4.72; 1.52; 4.16; 4.48; 2.40; 17.28. III: 3.28; 1.44; 2.80; 3.20; 1.60; 12.32. IV: 4.64; 1.52; 4.08; 5.28; 1.20; 16.72. Palp: 1.84; 1.12, 1.12; 1.28; 6.08.

Colour (in alcohol *cf.* colour in life, Fig. 44a–c). Carapace yellow brown with light pile of fine black hairs, central area to eyes burgundy, two black patches on posterior corners. Abdomen with strong constriction at two-thirds with fawn brown flanks. Chelicerae with dark inverted V. *Eyes.* Group width/headwidth=0.67 through PLE, 0.68 through mid-eye group. OQ front, back, long: 19, 30, 17. MOQ front, back, long: 12, 17, 8. AME: ALE: PME: PLE, 10: 6: 13: 13. PER in two lines separated by third of PME diameter; AER in 2 lines. Chelicerae with 2 large teeth on promargin, 4 on retromargin. STC with 6 long teeth; ITC bare. Scopula entirely absent. *Spines.* Pedal patellae with triad. Palp: fe p1d1.2r1; pa p1d1.1; ti p2d1. Palp (Figs 46a, b, 47a). Cymbium of male palp long, 1.14 times longer than tibia; retrobasal lobe thumb-like with ledge narrowing anteriorly. RTA retrolateral, clearly subdistal; VTA a low chelate lobe. Transverse part of tegulum slightly diagonal, DTP broad thumb-like.

Allotype female QM S104916. Carapace 3.80 long, 3.60 wide. Abdomen 4.04 long, 2.40 wide. Total, 7.84.

I: 3.68; 1.60; 3.96; 3.28; 2.04; 14.56. II: 3.84; 1.00; 3.48; 3.24; 1.88; 13.44. III: 3.04; 1.00; 2.36; 2.28; 1.12; 9.80. IV: 4.32; 1.12; 3.28; 4.12; 2.28; 15.12. Palp: 1.24; 0.68; 0.80; 1.28; 4.00.

Carapace and abdomen pattern similar to male with more strongly defined bands on posterior corners of carapace. Median dark inverted V on inner diagonals of cheliceral face. Abdomen laterally dark with well defined pallid venter. *Eyes.* Group width/headwidth=0.61 through PLE, 0.63 through mid-eye group. OQ front, back, long: 22, 31, 21. MOQ front, back, long: 10, 18, 10. AME: ALE: PME: PLE, 10: 6: 13: 12. PER cuts through mid-curve of caput shoulder. AER with 20% overlap; PER in two lines well separated by 1 diameter of PME. Chelicerae, 2p, 4r. STC with 8 teeth, ITC, 0. Scopula in lateral bands only on metatarsi and tarsi I–IIII. Group of long hairs (not tufts) only below *Claws.* Palp spines: fe p1d1.2r1; pa p1d1r1; ti p2d1; ta p2r1. Pedal patellae with triad. Epigyne. Overall, 1.25 times longer than wide; anteriorly narrow median scape delimiting spindle-shaped opercula with pear-shaped smooth lateral ridges narrowing in distal third with wide posterior median septum extending to epigastric ridge; internally, a short sinuous duct forming three loops in basal two-fifths (Fig. 46d).

Distribution, habitat and biology. Known only from rainforest at Mt Glorious in south-eastern Queensland; the spiders were found hunting on green leaves on low plants at night.

Variation. *Colour Pattern* (Figs 44a–c, 45). The diversity in colour patterns in one population at Mt Glorious is remarkable. However, the photographer, Ben Revell, also took photographs but did not capture *Ornodolomedes* from Nightcap Range, north-eastern New South Wales, as well as Mt Tamborine in south-east Queensland. The pattern types of *O. mickfanningi* (Fig. 50a, b) are similar to those of *O. benrevelli* (Figs 44a–c, 45). Hence, it is hypothesised that the diversity of patterns seems then to cover a number of species.

Ornodolomedes gorenpul sp. nov.
(Figs 5e, 48a, b, 49a–d. Map 4)

Etymology. The species is named for Gorenpul, the name of one of the aboriginal groups on North Stradbroke Island.

Common name. Gorenpul sprite.

Material examined. Queensland: holotype male, Enterprise Mine, Blackbutt site 1, 27°33'S, 153°27'E, Blackbutt, hand collection, 9 Jan 2002, Queensland Museum Party, QM S55979. Paratypes. Queensland: 1 ma., 2 fem., same data as holotype, QM S108401; 1 fem., Enterprise Mine, Scribbly Gum site 3, 27°35'S, 153°27'E, scrubby gully, hand collection, 10 Jan 2002, Queensland Museum Party, QM S55969; 1 ma., Enterprise Mine, Blackbutt site 3, 27°34'S, 153°28'E, Blackbutt, malaise trap, 8–22 Jan 2002, C. Burwell,

S. Wright, QM S55975; 1 fem., Enterprise Mine, Mallee (heath) site 1, 27°34′S, 153°26′E, Mallee, hand collection, 7 Jan 2002, Queensland Museum Party, QM S55965; 1 fem., North Stradbroke Is., Central, night collection, 6 Jan 2002, R. Raven, B. Baehr, QM S80519; 5 fem., Enterprise Mine, Scribbly Gum site 3, 27°35′S, 153°27′E, scrubby gully, hand collection, 10 Jan 2002, Queensland Museum Party, QM S55492; 1 ma., Bribie Island, 27°03′30″S 153°11′32″E, 19 Dec 1997, malaise Trap, N. Power, AM KS69519.

Diagnosis. The male palp bulb is very similar to that of *O. benrevelli* sp. nov. in that the RTA is subdistal, males differ in the relatively shorter palpal tibia and the RTA is quite short and indistinct (Fig. 49a, b). Females differ from those of all other species in having a wide distal septum (Fig. 49d).

Description. Holotype male QM S55979. Carapace 3.88 long, 3.32 wide. Abdomen 4.32 long, 2.44 wide. Total, 8.20.

I: 4.72; 1.84; 4.80; 4.24; 1.84; 17.44. II: 4.32; 1.60; 4.40; 3.52; 1.28; 15.12. III: 4.00; 1.60; 3.28; 3.44; 1.44; 13.76. IV: 5.12; 1.60; 3.84; 4.64; 1.76; 16.96. Palp: 1.92; 0.72; 0.64; 1.20; 4.48.

Carapace brown with moderately short brown hairs, margins dark. Abdomen dorsally with dark ostiate region, darker mottling laterally. *Spines.* I, II: fe p3d3r4; pa p1d1r1; ti p1d1–2r1v2.2.2+2 distal; me p3r3v2.2.2+ 2 short. III: fe p5d3r4; pa as I; ti p2d1–2r2v2.2.2; me p3r3v2.2.2. IV: as III but fe p4–5d3r4–5. Palp: fe p1–2d1.2r1; pa p1r1d1; ti p2d1. *Eyes.* Group width/headwidth=0.85 through PLE, 0.60 through mid-eye group. OQ front, back, long: 40, 68, 40. MOQ front, back, long: 23, 35, 21. AME: ALE: PME: PLE, 8: 11: 12: 11. PER well anterior to mid-curve of caput shoulder. AER with 30% overlap; PER two well separated lines. Chelicerae 2p, 4r; fang broad for most of its length. Tarsi straight; PTF distinct; no plumose hairs. Sternum cordate, narrows from II/III. Serrula long, sinuous. Labium slightly longer than wide. Two irregular rows of trichobothria on tarsi; distal line of 6 on metatarsi. Palp (Fig. 49a, b). Cymbium retrobasally with rounded process and long retroventral ridge; tibia clearly shorter than cymbium; RTA subdistal, simple, low curved ridge set mid-retrolaterally; VTA formed of two juxtaposed trianguloid lobes. Bulb with long transverse, slightly diagonal tegulum and digitiform DTP beside by large flared MA arising from broad base.

Female QM S108401. Carapace 3.00 long, 2.56 wide. Abdomen 3.60 long, 2.28 wide. Total, 6.6.

I: 3.50; 1.44; 3.06; 2.69; 1.00; 11.69. II: 3.50; 1.00; 2.88; 2.25; 0.75; 10.38. III (?regenerated): 2.50; 0.94; 2.06; 2.06; 0.94; 8.50. IV: 3.19; 1.25; 2.69; 2.56; 1.25; 10.94. Palp: 1.13; 0.50; 0.63;1.00; 3.25.

Colour. Carapace yellow brown with narrow dark edge and thin dark strial scallops. Legs yellow brown, III dark ventrally, less so on IV. Abdomen anteriorly with median invagination making two "shoulders", unpigmented arrow like ostiate region flanked by large white areas with two long dark bars posteriorly, laterally with dark diagonal bars, ventrally pallid; cluster of long bristles preject forward between PME, cluster of long procurved bristles over PLE. *Eyes.* Group width/headwidth= 0.66 through PLE, 0.55 through mid-eye group. OQ front, back, long: 34, 59, 38. MOQ front, back, long: 18, 30, 22. AME: ALE: PME: PLE, 7: 6: 9: 11. PER in two lines separated by 0.4 of PME diameter; AER with 50% overlap. PLE well behind clypeal shoulder. Chelicerae with one small and 2 large teeth on promargin, 4 on retromargin. STC with *ca.* 7 long teeth; ITC bare. Scopula absent. *Spines.* Tibiae I, II ventrally with three pairs of long (50% overlap) strong spines, none on distal edge; metatarsi I, II ventrally with two proximal pairs very long, each half length of metatarsus, and distal shorter (0.4 of basals) pair. Legs I, II: femora p4d3r3. Pedal patellae p1d1r1. Palp: fe p1d1.1.1r1; pa p1d1; ti p2d1; ta p2v2. STC with 6–7 long teeth; ITC bare.

Epigyne (Fig. 49c, d). Overall, *ca.* 1.47 times longer than wide; wide median scape delimiting irregular opercula with sinuous lateral ridges in distal 0.4 with posterior median lobe to epigastric ridge; internally, a long sinuous duct forming two loops for length with ental loop clearly shorter (Fig. 49d).

Distribution and habitat. Known only from closed Blackbutt forest on North Stradbroke Island and just north on Bribie Island, south-east Queensland.

Ornodolomedes mickfanningi sp. nov.
(Figs 3f, h, 5f, 7f, 50a–d, 51a–d, 52a–d. Map 4)

Etymology. The species epithet is conferred by Hector Manuel Osorio Gonzalez Filho as part of the launch of the World Science Festival, Brisbane, at the Queensland Museum in March 2017. It is in honour of Australian surfer, Mick Fanning, whose path to surfing greatness has incorporated all the attributes of a champion, including overcoming personal tragedy, career-threatening injury and one of sport's greatest competitive dynasties to reach surfing's highest echelon three times. He has a love for water and has a strong Queensland connection with his favourite "break" being at Queensland's iconic Snapper Rocks at Coolangatta.

Common Name. The species common name, Masked wood sprite, was conferred by Ricardo Leite as part of the launch of the World Science Festival Brisbane at the Queensland Museum in March 2017.

Material examined. Queensland: Lamington NP, IBISCA survey: holotype male, 28.155°S 153.139°E, 282 m, site 300B, hand collecting, 6 Oct 2006, B. Baehr, QM S104681. Paratypes: fem., 28.192°S 153.124°E, 775 m, site 700B, 16–21 Oct 2006, R. Menendez, G. Monteith, QM S76373; 2 ma., 28.148°S 153.137°E, 267 m, site 300A, 16–21 Oct 2006, flight intercept trap, G. Monteith, QM S76251; fem., 28.148°S 153.137°E, 267 m, site 300A, 6–9 Oct 2006, rainforest, pitfall traps, K. Staunton, QM S81158; ma., 28.148°S 153°137'E, 267 m, site 300A, 16–21 Oct 2006, dung pitfalls, R. Menendez, G. Monteith, QM S76341; ma., 28.207°S 153.137°E, 471 m, site 500D, 18–28 Oct 2006, flight intercept trap, G. Monteith, QM S76268; 1 ma., 28.142°S 153.133°E, 248 m, site 300D, 16–21 Oct 2006, dung pitfalls, R. Menendez, G. Monteith, QM S76418.

Diagnosis. The male palp is very similar to that of *O. benrevelli* sp. nov. in that the RTA is subdistal and quite long (Fig. 51a) but differs in that the RTA is more distal, the cymbium is distinctly longer than the tibia and the DTA is more slender. Females differ from those of *O. benrevelli* sp. nov. in that the spermathecal ducts are broader.

Description. Holotype male QM S104681. Carapace 4.00 long, 3.44 wide. Abdomen 4.64 long, 2.72 wide. Total, 8.6.

I: 4.40: 1.28; 5.04; 4.88; 3.20; 18.80. II: 4.40; 1.12; 4.88; 4.56; 2.72; 17.68. III: 3.60; 1.36; 3.04; 3.28; 1.92; 13.20. IV: 4.88; 1.52; 4.40; 5.68; 2.40; 18.88. Palp: 1.92; 0.80; 1.20; 1.36; 5.28.

Colour. Carapace yellow brown with slightly darker submarginal band most distinct posteriorly; red batwing-shaped area behind PER; paler central ovoid region. Abdomen pentagonal, posteriorly strongly tapered, partially accenuated by dark brown flanks; dorsally yellow brown with red-brown mottling, central paler regions; laterally with dark shoulders anterior. Median dark inverted V on inner diagonals of cheliceral "face". Legs fawn brown. *Eyes.* Group width/headwidth=0.62 through PLE, 0.50 through mid-eye group. OQ front, back, long: 27: 65: 40. MOQ front, back, long: 27: 33: 18. AME–AME, 7; AME–ALE, 3; PME–PME, 10; PME–PLE, 15. AME: ALE: PME: PLE, 10: 8: 12: 13. From front, AER with 50% overlap; PER in two lines separated by 0.16; from above, AER recurved. Chelicerae with 3 widely spaced teeth on promargin and retromargin. *Spines.* Legs I, II: fe p4d3r3; pa p1 apical r1; ti p2d2r2v.2.2.2.2; me p2r2v2.2 + distal whorl of 4. Leg III, IV: as above but, pa p1 d1(apical, not on II) r1; ti p2d2r2v.2.2.2; me p2r2 v1.1.1.1 + distal whorl of 4. Palp: fe p1d1.2r1; pa p1d1.1; ti p1d1 or 2. Palp (Fig. 51a, b): tibia long slender but shorter than cymbium; RTA subdistal, simple, rectanguloid lobe set mid-retrolaterally; VTA a low chelate lobe. Cymbium with small retroventral lobe and more distal ridge. Bulb with transverse tegulum and digitiform DTP overlaid by large unevenly flared MA.

Allotype female QM S81158. Carapace 4.08 long, 3.52 wide. Abdomen 5.24 long, 3.60wide. Total, 9.32.

I: 3.96; 1.68; 3.76; 3.60; 1.76; 14.76. II: 3.92; 1.72; 4.12; 3.36; 1.88; 15.00. III: 3.20; 1.40; 2.60; 2.68; 1.28; 11.16. IV: 4.32; 1.48; 3.24; 4.48; 1.88; 15.40. Palp: 1.40; 0.76; 0.88; 1.16; 4.20.

Carapace orange brown with two dark ovoid areas submarginally in posterior corners and rhomboidal outline prefoveal zone; tufts of white hair between PME and over PLE. Abdomen pentagonal with dark anterior lateral corners and posterior lateral edges; tufts of white hair on legs and abdomen. Palpal tarsus, distal pedal tibiae,and band on metatarsi brown. *Eyes.* Group width/headwidth=0.60 through PLE, 0.46 through mid-eye group. OQ front, back, long: 35, 66, 40. MOQ front, back, long: 25, 37, 20. AME: ALE: PME: PLE, 10: 7: 15: 11. Caput

shoulder weakly defined. AER with *ca.* 15% overlap; PER in two lines well separated by half diameter of PME. Chelicerae, 2p, 4r. STC with *ca.* 10 teeth; ITC, 0; palp 7–8. Scopula absent. Group of long hairs (not tufts) only below *Claws.* Palp: fe p1d1.2r1; pa triad; ti p2d1.1; ta p2r2. Pedal patellae with spine triad. Epigyne. Overall about as wide as long; short, narrow median scape delimiting two trianguloid opercula in *ca.* distal quarter, lateral ridges continue to epigastric ridge forming wide barrel-shaped septum; internally, sclerotised narrow ducts, overall confined to posterior two thirds, tightly folded (Fig. 51d).

Distribution, habitat and biology. Known only from the lower slopes up to 700 metres of the Lamington National Park, close to Canungra, in south-eastern Queensland; the spiders were found under logs and rocks in riverine gallery thickets in the day.

Ornodolomedes nebulosus sp. nov.
(Figs 2, 53a–e, 63a–c. Map 5a)

Etymology. The species epithet alludes to the clouds that almost permanently crown Mt Bellenden Ker, the type localilty.

Material examined. Queensland: holotype, male, Bellenden Ker Ra., cable tower 3, 1054 m, 17°16′S, 145°51′E, rainforest, 17–24 Oct 1981, EARTHWATCH/ Qld Museum, QM S27998; 1 fem. (non-type), Emerald Creek Falls picnic area, 17°03′11″S, 145°32′29″E, 3 Mar 2008, G. Milledge, H.M. Smith, AM KS103149.

Diagnosis. Males differ from those of *Ornodolomedes yalangi* sp. nov., in the presence of a long thorn-like process adjacent to base of DTP (Fig. 53b) and the more elaborate RTA (Fig. 53c–e). The female epigyne is most similar to that of *O. xypee* but differs in the longer double-folded ducts and externally in the folds appearing tear-shaped.

Description. Holotype male QM S27998. Carapace 2.90 long, 2.62 wide. Abdomen 3.57 long, 3.10 wide. Total, 6.5.

I: 3.81; 1.43; 3.81; 4.00; 1.71; 14.76. II: 3.76; 1.05; 3.24; 3.86; 1.76; 13.67. III: 3.43; 1.05; 3.24; 3.86; 1.76; 13.33. IV: 4.05; 1.05; 3.24; 4.52; 1.86; 14.71. Palp: 1.67; 0.48; 0.67; 1.43; 4.24.

Carapace with pile of short fine hairs; yellow brown with black bristles in striae and marginally beside PLE. Abdomen dorsally with two large ovoid guanine patches evident, laterally brown edges also with guanine; legs paler than carapace with black patches proximally on femora I–IV and mottling on tibiae I–IV. *Eyes.* Group width/headwidth=0.68 through PLE, 0.57 through mid-eye group. OQ front, back, long: 36, 54, 37. MOQ front, back, long: 19, 29, 20. AME: ALE: PME: PLE, 8: 7: 10: 10. PLE at mid-shoulder. AER with *ca.* 40–50 overlap; PER two well separated lines. Chelicerae: 2p, 3r. STC with *ca.* 6–7 teeth; ITC, 0. Scopula absent. Group of long hairs (not tufts) only below claws. *Spines.* Three basal paired spines on ventral metatarsi and tarsi I–II just overlapping. Palp: fe p1d1.2r1; pa p1d1.1r1; ti p1d1. Pedal patellae with spine triad. Palp (Fig. 53a–e). Cymbium much longer than tibia; RTA just proximal of midlength, large deeply concave, laterally set retrodorsal but just above retrolateral; VTA rectanguloid, deeply bipartite. Cymbium with broad retroventral flange and elongate lobe. Tegulum short, concave on proximal edge; DTP broad, straight, bullet-shaped with thorn-like process adjacent (Fig. 53b); MA with narrow base and well flared apically.

Female AM KS103149. Carapace 5.25 long, 4.25 wide. Abdomen 5.75 long, 4.25 wide. Total, 11.

I: 5.63, 2.00, 4.88, 4.38, 1.75, 18.63. II: 5.63, 2.13, 4.63, 4.25, 1.88, 18.50. III: 4.38, 1.75, 3.88, 4.13, 1.75, 15.88. IV: 5.38, 1.75, 4.38, 5.63, 1.50, 18.63. Palp: 2.00, 0.75, 1.00, –, 1.50, 5.25.

Carapace orange brown with darker hair medially, edges of posterior corners dark; legs banded black and fawn; femora mottled. Abdomen pentagonal, anteriorly invaginated, dorsally with white anterior corners, dark ostiate dagger-shape. Overall pattern like that of *O. mickfanningi. Eyes.* Group width/headwidth=0.69 through PLE, 0.57 through mid-eye group.

OQ front, back, long: 71, 85, 65. MOQ front, back, long: 24, 40, 22. AME:ALE:PME:PLE, 10: 8: 18: 20. Back eye row is two contiguous lines, AER with 50% overlap. Caput "shoulder" in front of PER. Chelicerae with three teeth on promargin, 3–4 on retromargin. *Claws.* STC on

I with 5-7 long teeth; ITC bare; palp with 3-4 teeth. Scopula absent. *Spines.* Slight overlap of ventral spines on tibie I, II. Pedal patellae with triad. Palp: fe p1d1.1.2r2; pa p1d1; ti p2d1.1; ta v2.

Remarks. The male and female were taken at highly disparate altitudes (over 1000 metres vs 200 metres) and thus the female is not considered a paratype.

Distribution and habitat. Known only from high altitude (1054 m) rainforest at Mt Bellenden Ker, and at Emerald Creek Falls, just to the east, north-east Queensland.

Ornodolomedes yalangi sp. nov.
(Figs 54a–g, 63d–f. Map 5b)

Etymology. The species epithet is from the aboriginal name of the tribe in the Mossman area.

Material examined. Queensland: holotype male, Mossman Bluff Track, 5–10 km W Mossman, 16°28′S, 145°22′E, flight trap, 20 Dec 1989–15 Jan 1990, G. Monteith, G. Thompson, ANZSES Expedition, QM S16718; 1 ma., 1 fem., same data but 20–24 Dec 1989, QM S108120; 1 ma., same data but 16–30 Dec 1989, QM S108121; 1 ma., same data but 17–31 Dec 1989, QM S108122; 1 fem., same data but 21 Dec 1989, QM S108124; 2 ma., same data but 1–16 Jan 1990, QM S108126; 1 ma., Stewart Ck, Mt Spurgeon, 16°28′S, 145°12′E, 15–21 Oct 1989, G. Monteith, QM S108125; 1 ma., 1 juv. fem., Tully River crossing, 10 km S Koombooloomba Dam, 17°55′S 145°37′E, flight intercept trap and pitfall, 8 Dec 1989–4 Jan 1990, G. Monteith, G. Thompson, H. Janetzki, QMS34799; 1 ma., same data as holotype, QM S108407; 1 ma., Thornton Peak, 16°10′S 145°23′E, 20–27 Sep 1989, G. Monteith, QM S108127.

Diagnosis. Males are most similar to those of *Ornodolomedes nebulosus* sp. nov. but differ in the shorter, less elaborate RTA, less elaborate abdominal pattern and the absence of the thorn-like process beside the DTP. Female unknown.

Description. Holotype Male QM S59162. Carapace 2.79 long, 2.25 wide. Abdomen 3.17 long, 1.54 wide. Total, 6.0.

I: 3.63; 1.29; 4.08; 4.25; 2.50; 15.75. II: 3.42; 1.13; 3.67; 3.75; 2.42; 14.38. III: 2.71; 0.96; 2.29; 2.58; 1.38; 9.92. IV: 3.88; 0.96; 3.08; 4.13; 1.54; 13.58. Palp: 1.29; 0.42; 0.71; 0.92; 3.33.

Colour. Carapace yellowish with brownish tinge centrally and pale median band. Abdomen colour faded, paler ostiate zone with darker regions around it. Legs yellowish. *Eyes.* Group width/headwidth= 0.74 through PLE, 0.59 through mid-eye group. OQ front, back, long: 38, 54, 37. MOQ front, back, long: 22, 30, 19. PER in just two lines slightly separated; AER with *ca.* 30% overlap. Chelicerae with 2 large teeth on promargin, 4 on retromargin. STC with 6–7 long teeth; ITC bare. Scopula absent. *Spines.* Pedal patellae with triad. Palp: fe p1d1.2r1; pa p1d1r1; ti d1. Palp (Figs 54a–g, 63d–f). Cymbium long, 1.3 times longer than tibia. RTA small, apically unequally bifid, retrolateral; VTA simple, rounded; tegulum slightly diagonal; short, cucumiform DTP.

Distribution and habitat. Known only from rainforest in the Wet Tropics Heritage area in north-eastern Queensland.

Ornodolomedes starickí sp. nov.
(Figs 55a–d, 63g–i. Map 5d)

Etymology. The species epithet is in honour of Noel Starick, valued volunteer at both the Australian National Insect Collection, C.S.I.R.O., Canberra, and at the Queensland Museum.

Material examined. Victoria: holotype male, Copracambra NP, WB line, malaise over Beehive Ck, 27 km NNE Cann R., 37°20′01″S 149°14′12″E, 347 m, ANIC Bulk Sample 2608, 5 Dec 2004–11 Jan 2005, C. Lambkin, N. Starick, ANIC 42-002259.

Diagnosis. The male most closely resembles those of *O. yalangi* but differs in the RTA being broader and dorsally wider. Females unknown.

Description. Holotype male ANIC. Carapace 4.48 long, 3.76 wide. Abdomen 5.36 long, 3.04 wide. Total, 9.8.

I: 6.00; 2.00; 5.68; 6.00; 3.28; 22.96. II: 5.28; 2.08; 4.88; 4.88; 2.64; 19.76. III: 4.16; 1.60; 3.36; 3.36; 1.36; 13.84. IV: 5.60; 1.76; 4.48; 4.96; 1.84; 18.64. Palp: 2.64; 1.28; 0.96;1.68; 6.56.

Colour. Carapace brown with light pile of black hairs. Abdomen dark brown, mottled dorsally, with pale foliate pattern; pale flanks and venter. *Eyes.* Group width/headwidth=0.77 through PLE, 0.58 through mid-eye group. OQ front,

back, long: 25, 41, 24. MOQ front, back, long: 13, 21, 15. AME: ALE: PME: PLE, 10: 9: 15: 17. PER in two lines just separated; AER with 30% overlap. Chelicerae with one small and 2 large teeth on promargin, 4 on retromargin. STC with 6 long teeth; ITC with 1 tooth. Scopula absent. *Spines.* Fe I–IV, p5d3r5. Pedal patellae with triad, p1d1r1. Palp: fe p1d1.1.1.2r1; pa p1d1.1; ti p2d1. Palp (Fig. 55a–c). Tibia shorter than cymbium. RTA a wide raised retrodorsal flange; VTA conical; DTP apically bluntly rounded.

Distribution and habitat. Known only from wet forest in eastern Victoria.

Ornodolomedes southcotti sp. nov.
(Figs 56a–d, 57a, b. Map 5d)

Etymology. The species epithet is honour of Ronald Vernon Southcott (15 May 1918 in Adelaide – 9 April 1998), medical acarologist of South Australia, "the first native-born Australian to have a major impact on acarology in this country." (Halliday & Pearn, 1998)

Material examined. Type. South Australia: holotype male, Happy Valley Reservoir [35.083°S, 138.567°E], under bark of eucalypt, 30 Aug 1992, "Caren & Julie", SAM NN1997939; juv. fem. (non-type), same data as holotype.

Diagnosis. Males are unusual in having 3 spines (not 2 as for other congeners) on the dorsal palpal femur before the distal pair and differ from those of *O. staricki* by the VTA being apically rectanguloid (not bifid) and the RTA (viewed from RTAmax) having one point (vs 3 points) and the dorsal edge is quite short and rounded (Fig. 57a). Females unknown.

Description. Holotype Male SAM NN1997939. Carapace 5.28 long, 4.64 wide. Abdomen 6.72 long, 2.80 wide. Total, 12.0.

I: 6.32; 2.40; 6.48; 6.80; 4.24; 26.24. II: 5.76; 2.40; 6.40; 4.96; 2.80; 22.32. III: 5.12; 2.80; 4.56; 4.08; 1.76; 18.32. IV: 6.24; 2.24; 5.12; 5.60; 2.40; 21.60. Palp: 3.36; 1.20; 1.44; 1.84; 7.84.

Colour. Carapace cream-coloured, narrow dark edge with dark radial striae. Abdomen long, sub-pentagonal, ostiate region pale, darker mottling elsewhere; venter fawn with black flecking. Femora fawn with black flecking, like coxae and sternum. *Eyes.* Group width/headwidth=0.66 through PLE, 0.45 through mid-eye group. OQ front, back, long: 25, 45, 29. MOQ front, back, long: 13, 24, 18. AME: ALE: PME: PLE, 5: 4: 9: 7. PER in two lines separated by 0.5 of PME diameter; AER with 30% overlap. Chelicerae with 2 large teeth on promargin, 4 on retromargin. STC with 8 teeth; ITC bare. Scopula absent. *Spines.* Pedal patellae with triad. Palp: fe p1d1.1.1.2r1; pa p1d1.1; ti p2d1. Palp (Fig. 57a, b). Cymbium long, 1.44 times longer than tibia, retroventrally with long wide flange with small trianguloid basal lobe. RTA retrodorsal, subdistal, with long invaginated scoop; VTA a long low ridge. Tegulum short, DTP long subcylindrical curved; MA with broad base and apically flared.

Distribution and habitat. Known only from Happy Valley, near Adelaide, South Australia.

Ornodolomedes nicholsoni sp. nov.
(Figs 58a–d, 59a–f, 63j–l. Map 5e)

Etymology. The species epithet is in honour of Jack Nicholson, an actor who so brilliantly portrays diverse personalities.

Material Examined. Western Australia: Two Peoples Bay Nature Reserve, S. Comer, wet pitfall: holotype male, Lake Gardner, site MG14, 34°58′19″S, 118°10′30″E, 26 Jul–2 Aug 1994, WAM T65675. Paratypes: Western Australia: 1 ma., site MG01, Firebreak Valley bottom, 34°58′58″S, 118°11′18″E, 23 Oct 1995, 30 Oct 1995, WAM T27644; 1 fem., site MG07, bottom of R7 gully, 34°59′53″S, 118°11′52″E, 12–19 Apr 1994, WAM T67649; 1 fem., site MG10, below A-frame, Tick Flat, 34°59′26″S, 118°10′57″E, 14–21 Nov 1996, WAM T67660; 1 ma., site MG06, lower Robinsons Valley, 34°59′42″S, 118°11′58″E, 26 Jul–2 Aug 1994, WAM T65932. 'Glenbourne Farm', S. of Gracetown, dry pitfall, L.M. Marsh *et al.*: 1 ma., site 5, 33°54′40″S, 115°00′34″E, 27–28 Oct 2007, WAM T110912; 1 ma., site 5, 33°54′40″S, 115°00′34″E, 28–30 Oct 2006, WAM T111205; 1 ma., site 2, 33°54′50″S, 115°00′57″E, 25–2003, 27 Oct 2003, WAM T111262; 1 ma., site 3, 33°54′28″S, 115°00′49″E, 25–27 Oct 2003, WAM T111326; 1 ma., 1 allotype fem., site 5, 33°54′40″S, 115°00′34″E, 25–27 Oct 2003, WAM T111341; 2 ma., site 5, 33°54′40″S, 115°00′34″E, 26–28 Oct 2002, WAM T111346, T111358; 1 ma., site 1, 33°54′32″S, 115°00′24″E, 12–14 Oct 2012, WAM T133556; 1 ma., Two Peoples Bay, W. McKenzie, QM S61023; 1 ma., Boranup, 34°09′S 115°02′E, Karri forest, pitfall, 11–13 Dec 1990, A. Austin, WAM 98/1176; 1 ma., 2 fem., Pemberton, 34°30′S 115°05′E, 24 May 1905, J. Springett, AM KS115468.

Diagnosis. Males differ from those of the geographically closest *O. southcotti* sp. nov., in the longer palpal tibia (*ca.* 1.2 times longer than cymbium), the long simple conical RTA and the straight, almost triangular DTP. Males are most similar to those of *O. mickfanningi* but differ in the relatively much smaller median apophysis. Females are unique in the genus in having a trianguloid form of the median field (Fig. 59e) and the rectanguloid shape of the internal ducts (Fig. 59f).

Description. Holotype male WAM T65675. Carapace 5.04 long, 4.40 wide. Abdomen 4.96 long, 3.20 wide. Total, 10.0.

I: 6.48; 2.56; 6.24; 6.24; 3.60; 25.12. II: 6.16; 2.24; 5.84; 5.84; 2.96; 23.04. III: 5.12; 1.68; 4.40; 4.64; 2.08; 17.92. IV: 6.72; 1.92; 5.36; 6.64; 2.00; 22.64. Palp: 2.80; 0.80; 0.80; 1.76; 6.16.

Colour. Carapace yellow brown with light pile of darker hairs; no evident pattern. Abdomen laterally mottled, dark with medial foliate pallid zone, anteriorly pallid, convergent pallid edges; generally coffin-shape; venter pallid. *Eyes.* Set well back on shoulder. Group width/headwidth=0.69 through PLE, 0.49 through mid-eye group. OQ front, back, long: 27, 43, 29. MOQ front, back, long: 9, 14, 16. AME: ALE: PME: PLE, 6:5:9:8. Two lines of PER separated by one PME diameter; AER with 30–40% overlap. Chelicerae with 2 large teeth on promargin, 4 on retromargin. STC with *ca.* 6 teeth; ITC bare. Scopula absent. *Spines.* Pedal patellae with triad. Palp: fe p1d1.1.2r2; pa p2d1.1r1; ti p1r1. Palp (Fig. 59a–d). Cymbium long, 1.06 times longer than tibia. RTA distal, mid-retrolateral trianguloid; VTA a broad trianguloid mound; tegulum slightly diagonal, DTP almost straight short, digitiform.

Allotype Female WAM T111341. Carapace 5.20 long, 4.32 wide. Abdomen 6.80 long, 3.76 wide. Total, 12.00.

I: 4.40; 2.48; 4.64; 4.24; 2.24; 18.00. II: 4.56; 2.32; 4.56; 4.32; 1.92; 17.68. III: 4.00; 1.84; 3.60; 3.84; 1.60; 14.88. IV: 4.88; 2.00; 4.32; 5.20; 2.08; 18.48. Palp: 2.00; 1.20; 1.20; 1.92; 6.32.

Colour. Carapace yellowish with white hairs on caput, black hairs beside it and broadly around fovea. Abdomen pentagonal with two dark anterior shoulders; tufts of white hair posteriorly and laterally; venter flecked. *Eyes.* Group width/headwidth=0.67 through PLE, 0.61 through mid-eye group. OQ front, back, long: 55, 82, 53. MOQ front, back, long: 27, 48, 25. AME: ALE: PME: PLE, 12:8:20:20. PER is two well separated lines; AER with 15% overlap. AME on common mound. Chelicerae with one small and 2 large teeth on promargin, 4 on retromargin. STC with 8 long teeth; ITC with 2 teeth. Scopula lateral on tarsi I–II. Spines: Pedal patellae with triad: p1 d.1. Palp: fe p1d1.1.2r1; pa p1d1.1; ti p2r1; ta p2r2. Epigyne (Fig. 59e, f). Overall shape about as long as wide. Lateral lobes discontinuous, small posterior lobes. Median field occupies 0.80 of overall length. Slender inner spermathecal duct with single broad outer duct; internal ducts in rectanguloid shape.

Distribution and habitat. Known only from Two Peoples Bay and Glenbourne, south of Gracetown, south western Western Australia.

Ornodolomedes xypee sp. nov.

(Fig. 60a–c. Map 5c)

Etymology. The species epithet is an arbitrary combination of letters.

Material examined. Queensland: holotype female, Proserpine, Deadman Creek (site XY17), 20°30'S, 148°33'E, open forest, 13 Mar 2008, R.J. Raven, QM S86872. Paratypes: 1 fem. with eggs, Proserpine, Deadman Ck (site XY17), 20°30'S, 148°33'E, open forest, litter, 17 Mar 2008, R.J. Raven, QM S86503; 1 fem., Proserpine, Airport Drive, WSC track, site XY13, 20°29'S, 148°34'E, closed woodland, malaise trap, 13 Feb –7 Mar 2008, Queensland Museum Party, QM S85261.

Diagnosis. Females are unusual in the genus in the form of the epigyne which is very like that in females of *Dolomedes instabilis*, i.e. lateral lobes with a large median field. The female epigyne is most similar to that of *O. nebulosus* in that less extensive median field but differs in the almost globose ducts and externally in the pipe-like sigmoidal ducts. Males unknown.

Description. Holotype female QM S86872. Carapace 4.88 long, 4.24 wide. Abdomen 5.60 long, 2.96 wide. Total, 10.5.

I: 5.52; 2.24; 5.28; 4.64; 2.24; 19.92. II: 5.36; 2.32; 5.04; 4.32; 1.92; 18.96. III: 4.64; 1.92; 3.60; 4.16; 1.52; 15.84. IV: 5.68; 1.84; 4.56; 5.52; 1.84; 19.44. Palp: 1.76; 0.96; 1.04;1.84; 5.60.

Carapace yellow brown with fine black hair; eye region burgundy. Abdomen dorsally with dark ostiae region, laterally pallid. *Eyes.* Group width/headwidth= 0.69 through PLE, 0.55 through mid-eye group. OQ front, back, long: 28, 45, 26. MOQ front, back, long: 15, 20, 15. PER in two lines just separated; AER with 60% overlap. Chelicerae p3, r3. PTF extends diagonally from venter almost to dorsum. STC with 6 long teeth; ITC bare; palpal claw with 4–5 teeth. Scopula absent. *Spines.* Normal spination but ventral tibiae I, II with three pairs of strong overlapping spines and one distal pair; metatarsi I, II, similar with two pairs plus smaller distal pair. Pedal patellae with p1d1r1 all weak or p1d1.1.r1. Palp: fe p1d1.2r1; pa p1d1.1r1; ti p2d1.1; ta p2d1r2. Epigyne (Fig. 60b, c). External, narrow median scape delimiting two slightly irregular sub-circular opercula in anterior 0.40–0.45 of epigyne, lateral ridges continue to epigastric ridge forming wide trianguloid septum; internally, highly sclerotised broad ducts, overall confined to posterior third, tightly folded.

Distribution and habitat. Known only from riverine rainforest just south of Proserpine in north-eastern Queensland.

Ornodolomedes marshi sp. nov.
(Figs 61a–c, 62a–d. Map 5d)

Etymology. The species epithet is in honour of Mr John Marsh, a legend in the Ingham area.

Material examined. Queensland: holotype male, Mt Spec NP, 19°00'S, 146° 12'E, rainforest, 15 Sep 1979, K. McDonald, QM S28805. Paratypes: 2 ma., same data as holotype, QM S108402.

Diagnosis (Figs 61a–c, 62a–d). The male most closely resembles those of *O. nicholsoni* but differs in the palpal tibia being shorter than the cymbium. Female unknown.

Description. Holotype Male QM S28805. Carapace 2.72 long, 2.50 wide. Abdomen 3.48 long, 1.60 wide. Total, 6.4.

I: 4.16; 1.44; 4.64; 4.96; 2.80; 18.00. II: 4.24; 1.36; 4.16; 4.32; 2.40; 16.48. III: 2.64; 1.04; 2.48; 2.80; 1.20; 10.16. IV: 4.24; 1.20; 3.60; 5.12; 2.08; 16.24. Palp: 1.68; 0.56; 0.80; 0.88; 3.92.

Colour. Entirely yellow brown. *Eyes.* Group width/headwidth= 0.74 through PLE, 0.80 through mid-eye group. OQ front, back, long: 46, 48, 32. MOQ front, back, long: 21, 30, 25. PER in two lines touching; AER with 15% overlap. STC with 7 long teeth; ITC bare. Scopula absent. *Spines.* Pedal patellae with d1w.1r1. Palp: fe p1d1.1.1r1; pa r1; ti p2d1. Palp (Figs 61a, b, 62a, b, d). Tibia shorter than cymbium. RTA retrodorsal, short, bifid; VTA rectanguloid; DTP strongly curved at mid-length, apically blunt.

Distribution and habitat. Known only from rainforest at Mt Spec, near Townsville in north-eastern Queensland.

Mangromedes Raven, gen. nov.

Etymology. The genus name is formed from Mangroves, in which the spiders occur, and *Dolomedes*; the gender is masculine.

Diagnosis. Males differ from those of *Dolomedes* and *Ornodolomedes*, gen. nov., in the deep basally divided RTA (Figs 65b, 67b), the embolus rests on the prolateral edge, and as the DTP is rectanguloid, set on a short tegulum (Figs 65a, 67a); females are unique in the Australian Pisauridae in the very wide long epigynal "wings" (Fig. 65c–e). Like *Ornodolomedes*, gen. nov., the ventral spines on tibiae and metatarsi I, II are very long and overlapping (Fig. 7d) unlike the shorter spines in *Dolomedes* (Fig. 7a–c).

Type species. *Mangromedes kochi* (Roewer, 1951).

Description. Carapace saddle-shaped in profile, lowest at fovea (Fig. 66g). Carapace (male) about as wide as long; eye group *ca.* 0.7 of head width; from above, AER strongly recurved so ALE overlaps with AME, rows as 2.4.2, PER recurved, just forming 2 lines. AME clearly larger than ALE but clearly smaller than eyes of PER, all of similar size. Eyes of AER similar interspaces and PME clearly closer than to PLE. Front in front, AER recurved with ALE overlapping extent of AME to 0–50%, top edge of ALE=bottom edge of PLE. AER

wider than second row (PME) (Fig. 66b), AER width less than PLE–PLE, AME as big as or bigger than PME much smaller than PME and not on tubercle (Fig. 66b); AER about 0.7 of width of PER. Clypeus with steep face, caput clearly lower than thoracic region. Serrula long, trochanters notched, insignificant fang shield. Tarsi slender, not pseudosegmented; PTF absent. Basal article of posterior lateral spinnerets longer than wide cylindrical, apical long, conical. Large white cheliceral boss with sclerotised edge. Chelicerae with 3 prolateral and 4 retrolateral teeth. Male palpal bulb of *Dolomedes* type with deeply divided RTA (Figs 65b, 66d), apical cymbium slender coniform, tegulum small with large rectanguloid DTP; embolus rests on prolateral edge; median apophysis short, widens quickly. Epigyne with wide sclerotised lateral extensions along epigastric groove (Fig. 65c–e); internally simple. Males and females of similar size. Strictly nocturnal spiders hunting freely in mangroves (Fig. 64a–d) on the mud and on trees, roots and rotting wood.

Included species. *Mangromedes kochi* (Roewer, 1951), *Mangromedes porosus* sp. nov.

Remarks. Given that the spiders are mangrove inhabitants, searches on the western side of Cape York and west of Kakadu seemed prudent. However, searches by RJR for *Mangromedes* in the harbour mangroves of Darwin and Weipa were unsuccessful; in Weipa, an unnamed lycosid occupies the mangroves in the intertidal zone.

Mangromedes kochi (Roewer, 1951), new combination

(Figs 3e, g, h, 5d, 7d, 64a–d, 65a–e. Map 5f)

Dolomedes elegans L. Koch, 1876: 861, pl. 73, fig. 6; Junior primary homonym of *Dolomedes elegans* Taczanowski, 1873.

Nilus elegans: Simon 1898: 290.

Nilus kochi Roewer, 1951: 438 (replacement name); Jäger, 2011: 5 (noted as misplaced, per RJR).

Material examined. Queensland: holotype male, Port Mackay, Museum Godeffroy No. 14629, ZMH, examined.

Other Material examined. Queensland: 1 ma., Jacobs Well Scientific Reserve, 27°34′S 153°30′E G. Leiper, 10 June 1997, QM S34613; 1 ma., Kangaroo Is., Moreton Bay, 27°34′S 153°30′E, 18 Nov 1990, R. Raven, A. Luck, QM S17687; 1 fem., Shute Harbour, 20°18′S 148°47′E, 4 Sep 1988, R. Raven, QM S14041; 5 ma., 5 fem., Tingalpa Creek, 27°29′13″S 153°11′10″E, 7 May 2016, R. Raven, MAGNT A004619, QMS, AM KS, WAM, SMF, ZHM; 2 ma., 4 fem., Victoria Creek, Forrest Beach, near Ingham, 18°43′S 146°19′E, mangroves at night, R. Raven, August, 2016, QM S108066, S108067; 2 fem., same data but July 2016, QM S108406; 1 ma., Wynnum, 23 Aug 2016, R. Raven, QM S108403; 1 ma., same data but, 21 May 2016, QM S108405; 2 fem., Chelsea Rd, Tingalpa, Ransome, with egg sac, 27°29.6″S, 153°11.1″E, 9 Dec 2004, R. Raven, QM S108404.

Diagnosis. Males differ from those of *Ma. porusus* in the more proximal position of the RTA (Fig. 65a, b); females have much wider epigynal "wings" (Fig. 65c–e).

Description. (Holotype colour faded; legs on left side and leg I on right side missing.) Male QM S34613. Carapace 3.13 long, 2.94 wide. Abdomen 2.56 long, 1.63 wide. Total length, 5.7.

I: 5.75, 1.75, 7.25, 7.63, 3.25, 25.63. II: 5.38, 1.88, 7.13, 7.88, 3.13, 25.38. III: 4.75, 1.50, 4.00, 5.00, 1.63, 16.88. IV: 5.50, 1.50, 4.88, 6.75, 2.63, 21.25. Palp: 2.13, 0.75, 0.88, –, 1.75, 5.50.

Colour. Carapace orange brown with black edges and darker large central zone; legs orange brown, no bands; abdomen shrunken, dark brown. Carapace. Broad, widest at fovea, with uniform cover of fine brown hairs, longest between eyes. from above, 2 strongly recurved rows or 4 rows with almost no overlap of lines; PME with grate-shaped tapetum. Relative sizes: AME 11, ALE, 8, PME 15, PLE 11. ALE and PLE on common tubercle, at least on one side. Interspaces: AME–AME, 11; PME–PME, 15; PME–PLE, 26. AME, 15; ALE, 8; PME, 21; PLE, 18. Eye group, 52 wide in front, 78 wide behind, 40 long. MOQ 31 wide in front, 40 wide behind, 25 long. *Spines.* I, II: fe pv2p3d3r4; pa p1 distal,r1; ti p3d3r3v2.2.2; me p3r3v2.2.2. III: fe p5d3r5; pa d1 distal; ti p2d2r2v2.2.2; me p3r3v2.2.2, strong. IV: fe p4d3r3; pa p1d1 distal; ti p2d2r2v2.2.2; me p3r3v2.2.2, strong. Palp: fe p1d1.1.1.2r1; pa d1r1; ti p2d1r1 + RTA. Trichobothria: 6–8 short in straight line for distal 1/8 on dorsal tarsi; 8–10 very short, in more or less straight row on metatarsi; 5–6 short in each of two rows on tibia for basal third. Claws: paired claws with one row of teeth, distal 5 long, strong and 2–3 times length of two proximal; no

teeth evident on ITC. Palp (Fig. 65a, b): Tibia of male palp short cylindrical, 0.5 of cymbium; 2.0 times longer than mid-width. RTA deeply divided, set in basal third. DTP irregularly rectanguloid with medial constriction; median apophysis basally wide, short and quickly widens strongly; VTA triangular; cymbium long, digitiform, cymbium process transverse, digitiform; distal embolus lies on prolateral edge.

Female QM S14041. Like male except: Carapace 3.60 long, 3.25 wide. Abdomen 4.00 long, 2.85 wide. Total, 7.60.

I: 4.60, 1.60, 4.40, 4.70, 1.80, 17.10. II: 4.55, 1.50, 4.40, 4.60, 1.70, 16.75. III: 4.00, 1.25, 3.30, 3.85, 1.45, 13.85. IV: 5.15, 1.35, 4.45, 6.05, 2.05, 19.05. Palp: 1.75, 0.75, 1.05, –, 1.65, 5.20.

Carapace mottled brown, centrally dark with paler lateral band. Abdomen dorsally dark, mottled, anterior lateral shoulders darker, ostiate region dark with pallid edges. *Eyes.* Group width/headwidth=0.65 through PLE, 0.53 through mid-eye group. OQ front, back, long: 47, 67, 44. MOQ front, back, long: 28, 37, 31. AME:ALE:PME:PLE, 11: 8: 13: 12. Back eye row is two well separated lines, AER lines contiguous with no overlap. Caput "shoulder" in front of PER. Chelicerae with one small and two large teeth on promargin, 4 on retromargin. *Claws.* STC on I with 4 long teeth basally; ITC bare; palp with two very ong distal teeth and at least one smaller basally. Scopula absent but ventral tarsi I–IV pallid (not pseudosegmented) with enlarged setae. *Spines.* Pedal patellae with d1r1, no prolateral on any. Palp: fe p1d1.1.2r2; pa p1d1r1; ti p2dv1; ta v2. Epigyne. Two slender lateral "wings" extending for width of main epigyne on each side, median scape absent, darkly sclerotised sinuous lateral ridges continue to epigastric rdge forming narrow cavity; internally, narrow duct leads from CO to pyriform transverse duct (Fig. 65c).

Variation. The described male (QM S34613) on the pedal patellae has a prolateral spine only on I on left side and II on the right side, otherwise a prolateral spine on the pedal patellae is absent in the described female and all other males.

Distribution and habitat (Fig. 64c, d; Map 5f). Known from mangroves and saltwater couch (grass) (*Sporobolus virginicus* (Linnaeus, 1753): Poaceae) from Ingham, coastal north-eastern Queensland, to Moreton Bay in southern Queensland.

Biology. A male from Moreton Bay was taken on grasses in a saltmarsh but the spiders are most common in mangroves adjacent to the sea (e.g. in Tingalpa Creek, Lota, Wynnum). They were seen running up the mangroves as the tide rose over the mudflats at night. Subsequently, they were taken low on mangrove trunks at low tide at night. Surveys of mangroves around Ingham (north-east Queensland) and Wynnum–Lota (south-east Queensland) found the spiders very common, up to 50 per square metre on logs and trunks but probably averaging 6–10 per m^2 through the aerial roots of the mangroves. The spiders are very fast moving and were found near the mud. When disturbed the spiders run into the cavities in the tree roots. Spiders placed in an aquarium of freshwater (household) were unable to walk on the surface whereas those on water in the mangroves were hunting over the surface. Males and females were taken in the mangroves from May until September with females carrying a small egg sac in the chelicerae in August and September. The egg sac is small with relatively few eggs.

Mangromedes porosus sp. nov.
(Figs 66a–g, 67a–e. Map 5f)

Etymology. The species epithet is from the species name of the Saltwater Crocodile, *Crocodylus porosus* Schneider, 1801, which are very common in the mangroves in which this species occurs in the Northern Territory.

Material examined. Northern Territory: holotype male, Point Farewell, Kakadu NP, 17 June 1982, W. Houston, (Australian Littoral Society no. K2099, site code KISQ3), MAGNT A004618; paratype (allotype), female, Australian Littoral Society K2450 site code KT6/03, Kakadu, East Alligator River, W. Houston, QM S107589.

Diagnosis. Males differ from those of *Ma. kochi* in the more distal position of the RTA (Fig. 66d); females differ in the epigynal "wings" being not so extensive (Fig. 66e).

Description. Holotype male MAGNT A004618. Carapace 3.00 long, 2.79 wide. Abdomen 2.91 long, 1.82 wide.

I: 4.53; 1.65; 2.06; 5.29; 1.82; 15.35. II: 4.35; 1.41; 5.00; 5.71; 2.12; 18.59. III: 4.24; 1.35; 4.06; 4.71; 1.53; 15.88. IV: 4.88; 1.29; 4.88; 6.29; 1.76; 19.12. Palp: 1.41; 0.59; 0.65; 1.41; 4.06.

Colour. Carapace: light brown with darker margins, three darker edges of posterior striae; eye group and clypeus in front of AME black, frontal chelicerae distomedially darker. Legs slightly paler than carapace, femora with darker mottling. Abdomen roughly pentagonal; ostiate region pallid, flanked by dark mottling with paired curving bands lateral of mid lone, pallid area just past widest point with pallid flanks. Clypeus slope steep. *Eyes.* Group width/head width= 0.59 through PLE, 0.58 through mid-eye group. OQ front, back, long: 28:40:25. MOQ front, back, long: 17:24:17. AME to clypeus slightly more than AME diameter. AME–AME, 3; AME–ALE, 3; PME–PME, 3; PME–PLE, 8. AME: ALE: PME: PLE, 9: 9: 10: 10. PER in two juxtaposed lines; from above, AER recurved, almost 2 lines, overlap=30%. Chelicerae with 4 teeth on promargin and retromargin. *Spines.* Legs I, II: fe p5d3r5; pa weak distal r1; ti p2d2r2v.2.2.2.2 + distal 2; me p2r2v2.2.2 + distal 2. Leg III: fe p5d3r4; pa d1 (distal weak); ti p2d2r2v.2.2.2; me p3r3 v2.2.2.IV: fe p5d3r3; otherwise as for III. Palp: fe p1d1.1.1.2r1; pa d1 distal, 1 weak basal; ti p2d1r1. Tarsi straight. Palp (Figs 66c, d, 67a–c, e). Tibia short, 0.5 of cymbium; 2.0 times longer than mid-width, widens gradually to retrolateral face with deeply divided RTA, set in distal third. DTP block-like; median apophysis short, quickly widens strongly; VTA indistinct; cymbium tip long, digitiform, basal cymbial process transverse; apical embolus on prolateral edge, terminating near median apophysis.

Allotype Female QM S107589. Carapace 3.68 long, 3.28 wide. Abdomen 4.08 long, 2.40 wide. Total, 7.8.

I: 4.80; 1.60; 4.56; 4.24; 1.20; 16.40. II: 4.64; 1.68; 4.64; 4.32; 1.60; 16.88. III: 4.00; 1.04; 3.60; 4.16; 1.44; 14.24. IV: 4.96; 1.36; 4.56; 5.52; 1.60; 18.00. Palp: 1.60; 0.72; 0.96; 1.44; 4.72.

Carapace orange brown with dark edges; abdomen ruptured. *Eyes.* Group width/headwidth=0.7 through PLE, 0.55 through PME. PLE set behind caput shoulder. OQ front, back, long: 25, 35, 21. MOQ front, back, long: 15, 19, 12. PER in two well separated lines; AER in two contiguous lines, no overlap. Chelicerae p3, r4. STC with 5 teeth; ITC with one tooth; palpal claw with 4 teeth. Scopula absent. *Spines.* Normal spination but ventral tibiae I, II with four pairs of strong overlapping spines; metatarsi I, II, similar with two pairs plus smaller distal pair. Pedal patellae with p1d1.1. Palp: fe p1d1.1.1.2r1; pa p1d1.1; ti p2d1.1; ta p2d1r1. Epigyne (Fig. 66e, f). With sinuous lateral lobes and apical "beak"; internally, simple ducts.

Distribution and habitat. Known only from mangroves at Point Farewell, Kakadu National Park and nearby Alligator River, Northern Territory.

Caledomedes gen. nov.

Etymology. The genus name is formed from New Caledonia, to which the spiders are endemic, and *Dolomedes*; the gender is masculine.

Diagnosis. Males differ from those of all other genera treated here in that the anterior eye row is not as wide as the back of the median ocular quadrangle (Fig. 68c), and the males have a deeply divided and proximal retrolateral tibial apophysis in combination with a long slender cymbium and embolus and fulcrum extending up the length of the cymbium (Figs 69a, b, 70a, b).

Description. AER only as wide as or narrower that width of second row (PME), AME much smaller than PME and on tubercle that overhands clypeus (Fig. 68b–d); AER *ca.* 0.7 of width of PER. Carapace in lateral view, low posteriorly with medial saddle rising to eye region (Fig. 68b). PTF absent; STC very long. Ventral spines on tibiae and metatarsi I, II long, but not overlapping. Male palp of *Dolomedes* grundplan. Nocturnal spiders hunting freely on the ground and vegetation in rainforest. Males and females of similar size.

Type species and species included. *Anoteropsis flavovittatus* Simon, 1880.

Relationships. The very long basal RTA of the male palp (Fig. 69) shows affinities with that *Mangromedes* (e.g. Fig. 67e). The elongate cymbium, embolus and fulcrum also occur in *Megadolomedes* (Figs 40b, 41b) and *Tasmomedes* (Fig. 38g).

Distribution and Habitat (Map 3b). Widespread in rainforests on New Caledonia.

History. Simon (1880) originally placed *Anoteropsis flavovittata* in the Pisauridae along with the type species, *Anoteropsis flavescens* L. Koch, 1878 (then known only from a female), and both species remained in the Pisauridae until Forster (1979) recognised that the type species was a lycosid. In revising *Anoteropsis,* Vink (2002) recognised that Simon had described a number of congeners in the genus *Lycosa* and that *A. flavovittata* was misplaced in the Lycosidae.

Caledomedes flavovittatus (Simon, 1880)

(Figs 4e, g, 5c, 68a–d, 69a–c, 70a–d. Map 3c)

Anoteropis (lapsus) flavovittata Simon, 1880: 166; Simon, 1898: 314, fig. 314; Berland, 1924a: 244, figs 195, 196 (not a lycosid, per Vink, 2002: 19).

Diagnosis. As for genus.

Material examined. New Caledonia: holotype male, MNHN, examined; ma., 2 fem., Mandjélia above Puebo, 11–13 May 1987, 600–750 m, G. Monteith, D. Cook, QM S73715; fem., Mt Panié, refuge, 1300 m, 20°34′S 164°46′E, 8–9 Nov 2001, C. Burwell, QM S108409; 1 ma., Mt Koghis, 500 m, 21°00′S, 165°00′E, pyrethrum knockdown, 27 Jan 2002, G. Monteith, QM S57196; 1 ma., Mt Mou, summit, 22°04′S, 166°21′E, rainforest, 24 May 1984, G. Monteith, D. Cook, QM S44625; 2 ma., Aoupinié, 20 km NE Poya, Niaouli, 21°10′S, 165°18′E, 18–19 May 1984, G. Monteith, D. Cook, QM S73713; 1 fem., Mt Dzumac, 22°03′S, 166°28′E, 23 May 1984, G. Monteith, D. Cook, QM S44622; 1 fem., Aoupinié, 21°10′S 165°17′E, pitfall, Oct 1992–12 Feb 1993, R. Raven, E. Guilbert, N. Platnick, M. Harvey, QM S37707; 1 fem., Aoupinié, top camp, 21°00′S 165°00′E, pyrethrum knockdown, 2–3 Nov 2001, C. Burwell, G. Monteith, QM S67859; 2 fem., Mt Panié, 20°35′S, 164°45′E, *Agathis montana* forest, 4–14 Dec 1990, R.J. Raven, QM S25461; 1 ma., Riviere Bleue, Kaori Geant (SC8948), 8 Feb 2002, C. Darling, QM S108411.

Description Male QM S73715. Carapace 3.68 long, 3.32 wide. Abdomen 4.08 long, 2.32 wide. Total, 7.8.

I: 6.75; 2.00; 7.25; 8.63; 3.25; 27.88. II: 7.38; 1.88; 7.13; 8.75; 3.50; 28.63. III: 6.38; 1.88; 5.88; 7.50; 2.50; 24.13. IV: 7.25; 1.88; 6.63; 9.88; 3.13; 28.75. Palp: 2.25; 1.00; 0.75; 2.25; 6.25.

Colour. Carapace yellowish brown with slightly darker strial scalloping. Abdomen yellow brown with 2 large white spots posteriorly, no ventral pattern. Eyes: group width/headwidth=0.69 through PLE, 0.55 through mid-eye group. OQ front, back, long: 27, 50, 34. MOQ front, back, long: 14, 29, 17. AME: ALE: PME: PLE, 5: 4: 13: 11. PER in two lines separated by 0.5 of PME diameter; AER with 25% overlap. Chelicerae with one small and 2 large teeth on promargin, 4–5 on retromargin. PTF absent. STC with ca. 7 long teeth; ITC long, bare. Scopula absent. Tarsi bent at about half length. *Spines.* Legs I, II: fe p3–5d3r4–5; pa p1d1r1. Pedal patellae with p1d1r1. Palp: fe p1d1.1.2r1; pa p1d1.1; ti p1.1r1. Palp (Figs 69, 70a, b). Tibia of male palp shorter than patella (Fig. 70b), RTA proximal with short ventral process and very long dorsal process; VTA digitiform; transverse part of tegulum straight, DTP curved cucumiform; embolus and conductor extend almost to tip of very long curved cymbium (Fig. 69c).

Female Mt Panié SC 8765. Carapace 5.20 long, 4.24 wide. Abdomen 5.60 long, 3.20 wide. Total, 10.8.

I: 6.08; 2.00; 6.00; 5.76; 2.56; 22.40. II: 6.40; 2.24; 5.84; 6.40; 2.40; 23.28. III: 6.00; 2.08; 5.20; 6.08; 2.08; 21.44. IV: 6.80; 2.16; 5.68; 7.68; 2.64; 24.96. Palp: 2.56; 1.20; 1.60; 2.56; 7.92.

Eyes. group width/headwidth=0.72 through PLE, 0.59 through mid-eye group. OQ front, back, long: 31, 52, 37. MOQ front, back, long: 20, 33, 15. AME: ALE: PME: PLE, 5: 5: 14: 13. PER in two lines separated by 0.5 of PME diameter; AER with 50% overlap. PTF absent. STC with *ca.* 6 long teeth; ITC long, bare. Scopula absent. Tarsi bent at about half length. *Spines.* Pedal patellae with p1d1r1. Palp: fe p1d1.1.2r1; pa p1d1.1; ti p1.1r1. Epigyne. Overall shape ovoid, clearly wider than long; lateral lobes curved,

widen distally, median field occupies full lenth; septum a short distal dome inset into margin. Internally, ducts occupy *ca.* 0.6 of length, three folds.

Distribution and habitat. As for genus.

Bradystichus Simon, 1884

Bradystichus Simon, 1884: CCXCIX. Type species *Bradystichus calligaster* Simon, 1884 by subsequent designation of Simon, 1898: 365; Platnick & Forster, 1993: 6.

Common name. New Caledonian mud wallower.

Diagnosis. Differs from all other genera by scopula on the prodorsal edge of the cymbium (Fig. 71a, b) as well as the combination of the minute third claw and the encrusted dorsal surfaces (Platnick & Forster, 1993) on the carapace, abdomen and legs (Fig. 1c).

Description. Male palp of *Dolomedes* type. Cuticle encrusted with soil. Carapace in lateral view similar to *Dolomedes* higher behind sloping down to eye region (as in Fig. 5g). Eyes of PER larger than those of AER and in two widely separated lines; AER about 0.7 of width of PER (Fig. 3c); ALE clearly smaller than AME. AER wide, edges cut through PLE. PTF present. Males slightly smaller than females. Rainforest spiders found under rocks and logs and in muddy mounds of leaves.

Included species. *Bradystichus calligaster* Simon, 1884, *Bradystichus crispatus* Simon, 1884, *Bradystichus panie* Platnick & Forster, 1993, *Bradystichus aoupinie* Platnick & Forster, 1993, *Bradystichus tanji* Platnick & Forster, 1993.

Distribution and Habitat. Rainforest areas in New Caledonia. The spiders occur under rocks and logs and when heavy rain causes surface water to sweep leaves in muddy mounds, the spiders are found in these muddy zones. In dry times, the spiders were found under logs and rocks.

Remarks. Since Platnick & Forster (1993) was a comprehensive revision of the genus with detailed morphology, only a minimal treatment is given here.

Bradystichus calligaster Simon, 1884
(Figs 1c, 3c, 6a, 71a–c. Map 3d)

Bradystichus calligaster Simon, 1884: CCXCIX; Platnick & Forster, 1993: 10. Holotype, female, Canala, New Caledonia, in MNHN, examined.

Remarks. The scopula on the prodorsal cymbium (Fig. 71a, b) is most pronounced in this species, it is well developed in *Bradystichus crispatus*, *Bradystichus aoupinie*, but only nominal in *Bradystichus panie* (types of all species examined).

Pisaurinae

History. Davies (1982) noted that *Dendrolycosa icadia* was known from mid-eastern and north eastern Queensland. Davies (1985) listed only *Dendrolycosa icadia* from Australia. Jäger (2011) revised *Dendrolycosa,* described the types (females) of *Dendrolycosa icadia* (L. Koch, 1876), and described the holotype female of a new species *De. yuka* from "Cap" which he considered was Cape York; no male of *Dendrolycosa* from Australia has been described; *Nilus kochi* Roewer, 1951 was left in abeyance for his work. Silva & Griswold (2013) provided an updated diagnosis for the genus worldwide; thus, the genus diagnosis provided here focusses on differences of the genus from other Australian pisaurids.

Inola Davies 1982 included *I. amicabilis* Davies, 1982, *I. cracentis* Davies, 1982 and *I. subtilis* Davies, 1982 from north Queensland; since then Tio & Humphrey (2010) added *I. daviesae.*

Dendrolycosa Doleschall, 1859

Dendrolycosa Doleschall, 1859: 51; Davies, 1985: 102; Jäger, 2011: 10; Silva, 2013a: 397.

Dianpisaura Zhang, Zhu & Song, 2004: 366, type *Pisaura lizhii* Zhang, 2000. First synonymised by Jäger, 2011: 10.

Type species. *Dendrolycosa fusca* Doleschall, 1859 by monotypy.

Diagnosis. Differs from *Inola*, the other sheet web building pisaurid in Australia, by the ALE being clearly the smallest eyes rather than be being as large if not larger than the PME and the anterior row being clearly recurved.

Description. Carapace low, long and almost flat in lateral view with slight medial saddle (Fig. 5b). Colour pattern A as in Jäger (2011).

All eyes similar in size; AER and PER recurved; rows 4.2.2; AER only slightly narrower (0.90) than PER (Fig. 73g). Chelicerae with 3 prolateral and 4 retrolateral. Tarsi straight. PTF for entire width. STC with *ca*. 8 teeth; ITC with 1 tooth. Spines: patellae I–IV, p1 distal 1 r1, all weak; palp p1, d1.1.weak; palpal femora with three spines proximally on dorsal edge followed by distal pair. Epigyne with curved lateral ridge, Y-shaped overall. Aboreal spiders building long sheet webs with retreat curling around stem of plant (Fig. 72b); found in open forest, heath and mangroves. Males and females of similar size.

Distribution (Map 6a). Australian Region–Queensland, Northern Territory, New Guinea, China, New Caledonia, Myanmar, India, Indonesia (Java, Sumatra), Malaysia, Nicobar Islands, Tanzania, Madagascar.

Dendrolycosa icadia (L. Koch, 1876)

(Figs 72a–c, 73a–g. Map 6a)

Dolomedes icadius L. Koch, 1876: 859, plate 73, fig. 5.
Dendrolycosa icadius: Davies, 1985: 102.
Dendrolycosa icadia: Jäger, 2011: 32, figs 147–149, 153–158, 167.

Material examined. Syntypes. Queensland: 1 juv. male and female, Rockhampton, ZMH MGH 14628, examined; 1 female, 1 penult. male, 1 juv. fem., Port Mackay, L. Koch Collection, BMNH 19.9.18.5558–60; 3 juv. females, Bowen, Keyserling collection, BMNH 1890.7.1.2842–4.

Other material examined. Queensland: 2 fem., Lords Table, east face, 22°40′S, 148°01′E, vine forest, 9 Jan 2006, R.J. Raven, QM S80175; 1 fem., Eurimbula, 24°07′S, 151°43′E, 13 Sep 1989–15 Sep 1989, QM S25943; 1 fem., Binjour Plateau, (Darlington Rd) Picnic ground, Swains Rd, 21 Dec 1997, QM S75695; 1 ma., 2 fem., Deepwater NP, 65 km NW Bundaberg, 24°32′S, 151°58′E, 20–26 Sep 1992, G. & S. Monteith, QM S25396; 1 ma., 1 juv., Rochedale SF, 27°37′S, 153°09′E, open forest, 20 Sep 1979, V. Davies, R. Raven, QM S4778; 3 fem., Red Falls NP, Lochwall Station, 19°55′S, 145°44′E, open forest, 16 Dec 2006, R.J. Raven, QM S76503; 1 ma., 2 fem., Atherton Tableland, near Mareeba, 17°00′S, 145°26′E, rainforest, Dec 1982, R.R. Jackson, QM S4791, 2; 2 fem., Dalrymple NP, site 2, 19°49′S, 146°05′E, semi-evergreen vine thicket, night collection, 13 Dec 2006, R.J. Raven, QM S79128; 1 fem., 1 penult. male, Wrattens Camp, via Widgee, 26°15′S, 152°22′E, rainforest, pitfall, 29 Dec 1974–28 Mar 1975, G. & S. Monteith, QM S30395; 1 fem., Yeppoon, 10 km SSE, 23°08′S, 150°45′E, 28 Nov 1986, I.K.B. Common, QM S7003; 1 fem., Eurimbula, 24°07′S, 151°43′E, 13–15 Sep 1989, QM S25944; 5 fem., Orchid Beach, Fraser Is., 24°58′S, 153°19′E, heathland, 1 Oct 1996, R.J. Raven, QM S31306; 1 ma., Rochford Scrub, site 7, 20°07′S, 146°37′E, bendee scrub, malaise trap, 12 Dec 2006–11 Feb 2007, G. Monteith, D. Cook, QM S76582; 2 fem., Broken R, Jack's Hill Gorge, 19°28′S, 144°46′E, foliage, 16 Jul 1995, P. Lawless & QM, QM S33285; 2 fem., Turtle Is., rainforest plantation, 17 Nov 1992, Schoena, Keen, QM S51188; 1 fem., Horn Is., Torres Strait, 10°37′S, 142°17′E, open forest, 2–8 Dec 1986, J. Gallon, QM S12344; 1 fem., Prince of Wales Is., Terry Beach, 10°41′S, 142°11′E, on tree trunks, 30 Jun 1976, E. Cameron, QM S28868; 1 fem., Saibai Is., Torres Strait, 9°23′S, 142°40′E, mangrove, 13 Jul 1975, H. Heatwole, E. Cameron, QM S28864; 3 fem., 1 penult. male, Horn Is., Torres Strait, 10°37′S, 142°17′E, woodland, 23–27 Dec 1975, H. Heatwole, E. Cameron, QM S28869; 1 ma., Hann Tableland, base, 16°56′40″S, 145°19′14″E, 23 May 2010, QM S104602; 2 fem., Goodnight Scrub, Burnett River, Sep 1987, QM S107094; 2 fem., 2 ma., Davies Creek, Nov 1971–Jan 1972, QM S107095; 3 fem., Mt Garnet, 24 Feb 1972, QM S107096; 1 fem., 4 juv., Chillago, 24 Apr 1978–26 Apr 1978, QM S107097; 3 fem., 1 juv. fem., Atherton Tableland near Mareeba, Dec 1982, QM S107099; 1 fem., 4 juv., 40 Mile Scrub, SW Mt Garnet, 9–14 Apr 1978, QM S107100. Solomon Islands: Uipi Island, 1 ma., 1 fem., 1 juv., 8°25′S, 157°56′E, beach, 4 Jul 1990, T. B. Churchill, QM S33845; 1 fem., Prince of Wales Is., Torres Strait, Terry Beach, 10°41′S, 142°09′E, 1 Jul 1976, E. Cameron, AM KS44294; 1 fem., "Queensland", 16°55′20″S 145°46′33″E, 1 Jul 1967, J. Child, AM KS115235; 1 fem., Morehead R., 15°07′S 143°40′E, 1 Jan 1994, M.S. Moulds, AM KS44294; 2 fem., Walkers Ck ca. 20 km N Normanton, 17°28′S 141°10′E, 17 Jul 1995, J. Thompson, M. Tio, S. Cowan, AM KS53193–4; 1 juv., Eurimbula SE of Gladstone, 24°11′S 151°50′E, 1 Mar 1975, Pitfall, C. Horseman, AM KS257. Northern Territory: 1 ma., 1 fem., Mindil Beach, 12°27′S 130°50′E, 2 Oct 1997, M. Humphrey, AM KS65153, 4.

Other localities. Juveniles given as locality, registration number. Queensland: Broken R, Southside Jack's Hill Gorge, 19°28′S, 144°46′E, QM S33279; Casey Ck, via Imbil, 26°28′S, 152°41′E, QM S30422; Fraser Is.: Orchid Beach, 24°57′S, 153°18′E, QM S38846, QM S42584; Dauan Is., Torres Strait, 9°25′S, 142°32′E, QM S28867; Mt Tamborine, Palm Grove, 27°56′S, 153°12′E, QM S30396; Tungi Ck, 26°40′S, 152°28′E, QM S30471. Horn Is., Torres Strait, 10°37′S, 142°17′E, TS, 24–29 Jan 1975, R.J. Raven, QM S28865; Saibai Is., Torres Strait, 9°23′S, 142°40′E, QM S28866; Wonga Beach, 16°19′25″S 145°25′39″E, AM KS86148. New South Wales: Whian Whian SF, 28°41′S, 153°19′E, QM S30439; Brindle Ck, Wiangaree SF, 28°28′S, 153°04′E, QM S30420; Victoria Pk, via Alstonville, 28°53′S, 153°23′E, QM S30352.

Type localities. Rockhampton, Bowen, Mackay, and Peak Downs, Queensland. However,

Davies (1985) reported only that of the syntypes in ZMH, i.e. Rockhampton.

Diagnosis. Males differ from those of *De. kakadu* sp. nov. in the ledged RTA, the less extensive tegulum, and extended cymbial prolateral mound (Fig. 73a, b). Females of *De. icadia* differ from those of *De. yuka* in the distinct anterior saddle anteriorly on the epigyne (Fig. 73c) and the reniform spermathecae (Fig. 73e).

Description. *Male* QM S104602. Carapace 4.35 long, 3.53 wide. Abdomen 5.12 long, 2.82 wide. Total, 9.5.

I: 5.69; 2.00; 5.56; 4.69; 1.88; 19.81. II: 5.69; 1.69; 5.50; 5.13; 2.13; 20.13. III: 4.81; 1.63; 3.75; 4.06; 1.69; 15.94. IV: 5.06; 1.69; 4.81; 5.63; 2.38; 19.56. Palp: 1.94; 1.13; 1.25; 1.88; 6.19.

Eyes. Group width/headwidth=0.62 through PLE, 0.50 through mid-eye group. OQ front, back, long: 33: 41: 30. MOQ front, back, long: 16: 20: 19. AME–AME, 6; AME–ALE, 4; PME–PME, 6; PME–PLE, 8. AME: ALE: PME: PLE, 6: 5: 7: 7. PER in two lines, AER recurved. Claws: STC on I with 6 long teeth; ITC, bare. Spines: patellae I, II, 1 p1 distal 1, weak b1. Tibiae I, II d0; III, IV, d1.1. Legs I, II: fe p5d3r5; pa p1r1; ti p2d2r2v.2.2.2.2; me p2r2v2.2 + distal whorl of 4. Leg III, IV: as above but, pa p1d1 (distal) r1; ti p2d2r2v.2.2.2; me p2r2 v1.1.1.1 + distal whorl of 4. Palp: fe p1d1.1.1.2r2; pa 0; ti p1r1.

Female QM S80175. As for male except: Carapace 5.19 long, 4.38 wide. Abdomen 9.50 long, 5.63 wide. Total, 14.7.

I: 6.06; 2.50; 4.81; 5.00; 1.94; 20.31. II: 6.13; 2.19; 4.81; 4.94; 2.06; 20.13. III: 5.31; 1.88; 4; 4.19; 1.69; 17.06. IV: 6.13; 2.06; 5.19; 5.94; 1.94; 21.25. Palp: 1.94; 1.13; 1.38; 1.88; 6.31.

Eyes. Group width/headwidth=0.65 through PLE, 0.69 through mid-eye group. OQ front, back, long: 67; 80, 62. MOQ front, back, long: 34; 40, 37. AME–AME, 10; AME–ALE, 4; PME–PME, 12; PME–PLE, 15. AME: ALE: PME: PLE, 13: 15: 14: 13. PER of two widely separated lines, AER recurved. Chelicerae with 3 teeth on promargin and retromargin. PTF distinct, diagonally for width of tarsus distally. *Spines*. Tibial spines weak; metatarsal spines long and strong but not overlapping. Palp: fe p1d1.1.1.2r1; pa p1d1r1w; ti p1d1; ta p1d1r2. Epigyne. Lateral lobes forming Y-shaped with median "bridge" with narrow neck; internally, apostrophe-shaped ducts directed diagonally.

Distribution. Davies (1986) listed the distribution as NE coastal in Queensland; Jäger (2011) saw only the types. The species seems to be extending its range in south-east Queensland. In 1976, during a week long QM survey at Lake Poona, no webs of *De. icadia* were noted. In 1998, in a similar habitat just north at Fraser Island, RJR noted the presence of large numbers of webs of *De. icadia* in the Waddy Point Camp Ground. The webs are built near mangroves and creeks but also have been found many kilometres from the coast in open bushland and on the edge of rainforest.

Remarks. Very small juveniles were found in webs that presumably they built.

Dendrolycosa kakadu sp. nov.

(Figs 5b, 74a–e. Map 6a)

Etymology. The species epithet is a noun in apposition taken from Kakadu National Park, Northern Territory, near which the species was taken.

Material Examined. Northern Territory: Holotype male, South Alligator Inn, 12°40'S, 132°30'E, rainforest, 7–9 Nov 1979, R.J. Raven, QM S104600. Paratypes: 3 ma., 4 fem., same data as holotype, QM S53981; 1 fem., same data as holotype, QM S104601; 1 fem., Radon Creek (dry), 14 Nov 1979, R. Raven, QM S107098.

Diagnosis. Males differ from those of *De. icadia* in the more extensive tegulum and different shapes of the median apophysis and RTA (Fig. 74b); females differ from those of *De. icadia* by the vertical, rather than inclined slope, of the spermathecae (Fig. 74e).

Description. Holotype male QM S104600. Carapace 4.67 long, 4.28 wide. Abdomen 6.39 long, wide 3.22. Total, 11.1.

I: 6.38; 2.81; 6.13; 6.56; 2.56; 24.44. II: 6.50; 2.75; 5.94; 6.31; 2.44; 23.94. III: 6.06; 2.25; 4.75; 5.13; 1.75; 19.94. IV: 7.00; 2.19; 5.69; 6.56; 2.13; 23.56. Palp: 2.13; 0.88; 1.00; 2.13; 6.13.

Carapace. Pile of silver hairs through *Eyes*. Abdomen with Jäger (2011) pattern type A.

Eyes. AME and half of ALE overhang clypeus. Group width/headwidth=0.59 through PLE, 0.75 through mid-eye group. OQ front, back, long, 63: 75: 52. MOQ front, back, long: 31: 51: 32. AME–AME, 7; AME–ALE, 6; PME–PME, 12; PME–PLE, 5. AME: ALE: PME: PLE, 12: 13: 12: 15. PER in two lines; from above, AER recurved. Chelicerae with 2 teeth on promargin, 3 on retromargin. Tarsi straight. Claws: STC on I with 7 long teeth; ITC bare. *Spines*. Patellae I–IV with p1r1 and one proximal and one distal dorsal. Legs I, II: fe p5d3r5; pa p1r1; ti p2d2r2v.2.2.2.2; me p2r2v1.1.1.1.1+ distal whorl of 4. Leg III, IV: as above but, pa p1d1 (distal) r1; ti p2d2r2v.2.2.2; me p2r2 v1.175.1.1 + distal whorl of 4. Palp: fe p1d1.1.2r2; pa 0; ti p1r1. Palp (Fig. 74a–c). Tibia of male palp short. RTA a long process, subapically lobed in ventral view, with short tooth-like apical process rounded lobe; cymbium retrobasally with broad flange beside rectanguloid plate; median apophysis and embolus contrasting shape.

Female QM S53981. Similar to male but: Epigyne. Lateral lobes set very wide (Fig. 74d) with median "bridge" with broad neck; internally, small reniform-shaped ducts directed subvertically.

Distribution and Habitat. Known from South Alligator River and mangroves along the Darwin Harbour, Northern Territory. A male and female taken west of this point, near Darwin, are *Dendrolycosa icadia* which are presumably introduced.

Dendrolycosa yuka Jäger, 2011

Dendrolycosa kochi Simon, 1898a: 285, 289; Blandin, 1979: 365, fig. 34 (*nomen nudum*).

Dendrolycosa yuka Jäger, 2011: 31, figs 138–140, 144–146, 167.

Material examined. Type. Holotype, female (MNHN), "Cap" (Jäger 2011 deduced this meant Cape York, following Blandin (1979)), E.S. 3.190, examined RJR.

Diagnosis. Females of *De. yuka* differ from those of *De. icadia* in the absence of a deep saddle (procurved ridge, arrow) anteriorly on the epigyne (Jäger, 2011, fig. 144) and the spermathecae are not reniform but rounded rectanguloid (Jäger, 2011, fig. 145).

Remarks. The epigyne of a female from Torres Strait (Fig. 73e, f; the tip of Cape York) shows no resemblance to that of *De. yuka* but could be conspecific with *De. sierwaldi* Jäger, 2011 (figs 141–143). However, the label on Simon's specimen (the holotype) is "Cap!" which is usually taken to be Cape Horn, South Africa. In the absence of females with a similar epigyne from Australia, even Cape York, the type locality is corrected to Cape Horn, South Africa. The nearest record to Cape Horn is that of *De. rossi* Silva & Griswold, 2013 fom Madagascar.

Perenethis L. Koch, 1878

Perenethis L. Koch, 1878: 980; Blandin, 1975: 378; Sierwald, 1997: 387. Type species. *Perenethis venusta* L. Koch, 1878 by monotypy

Pisaurellus Roewer, 1961b: 40, type *P. badius* Roewer, 1961. Synonymised by Sierwald, 1997: 395.

Diagnosis. *Perenethis* is unusual among the Australian pisaurids in the low profile of the carapace with a long low curving clypeus (Fig. 5a).

Description. Carapace very low, long and almost flat in lateral view with slight medial saddle, eye region curves down to chelicerae (Fig. 5a). Anterior edge of carapace is symmetrical procurved indents (Fig. 5a). Clypeus–AME vertical. Eyes all of similar size. AER clearly narrower (*ca.* 0.7) than PER (Fig. 75b) and from in front, procurved. ALE lower than AME and slightly smaller. AME on mound. Cheliceral boss with darkly sclerotised edge. Long bristles anterior to AME. Labium wider than long, 24: 18. Maxillae thumb-like; long black serrula. No feathery hairs. Male fang shield with only bristles. No scopula or preening combs. Trochanters deeply notched. PTF present. Male tarsi longer, straight, slender. STC I–IV with 9 long teeth; ITC distinct, curved, bare. posterior lateral spinnerets with digitiform apical segment. Cymbium long, lachrymoidal, no scopula. Males and females of similar size. Found on grass and low herbage, the spiders hunt freely with no web.

History. Zhang *et al.* (2004: fig. 1) found that *Perenethis* (with *Polyboea*) are the sister group of *Pisaura* and *Dendrolycosa* (as *Dianpisaura* Zhang, Zhu & Song, 2004), and they are the sister group of all other pisaurids (in their data set) with *Sphedanus* (as *Eurychoera)* plus *Qianlingula* as the basal sister group followed by *Hygropoda*, and they the sister group of *Dolomedes* plus *Nilus* (as

Thalassius). That work remains the last cladistic attempt (21 terminal taxa, 51 characters) to resolve the subfamilies of the Pisauridae.

Perenethis venusta L. Koch, 1878
(Figs 4f, 5a, 75a–c, 76a–d. Map 6b)

Perenethis venusta L. Koch, 1878: 980, plate 85, fig. 7; Davies, 1985: 104; Sierwald, 1997: 396, figs 42–47, 53, 57, 75, 76; Thorell, 1881: 372; Chrysanthus, 1967: 421, fig. 58; Sierwald, 1997: 396, figs 42–47, 53, 57, 75, 76; Chen & Chen, 2002: 32, figs 1A–F, 2A–D; Tanikawa & Ono, 2009: 220, figs 31–32.

Dolomedes stilatus Karsch, 1878: 814. New Synonymy.

Perenethis parkinsoni Dahl 1908: 228. Holotype female, Bismarck Archipelago, Ralum, Papua New Guinea; ZMHB 29 224, not examined. First synonymised by Sierwald (1997: 396).

Perenethis unifasciata: Chrysanthus, 1967a: 422, figs 53–57 (male and female misidentified, per Sierwald, 1997: 396); Barrion & Litsinger, 1995: 348, female; Jose, Sudhikumar & Sebastian, 2007: 127, fig. 1a–f.

Perenethis kawangisa Barrion & Litsinger, 1995: 345, holotype male, not examined. New Synonymy.

Material examined. Types. Queensland: Lectotype female (*Perenethis venusta*) and paralectotype female (Rockhampton and Peak Downs) in ZMH, designated by Sierwald (1997: 396); females, same data, BMNH, ZMB 3501. Western Australia: holotype male, (*Dolomedes stilatus*) ZMB, (as "Austr. occid."), examined.

Other material examined. Queensland: 2 fem., Normanby Station, 80 km NW Cooktown, 15°23′S, 144°52′E, Aug 1985, D. Bell, QM S16620; 1 ma., 1 fem., Ferny Hills, Brisbane, 27°28′S, 153°03′E, 13 Dec 1979, R.J. Raven, QM S14661; 3 ma., 5 fem., Ayr, 19°34′S, 147°27′E, 10 Jan 1974, V. Salanitri, QM S28787; 2 fem., Ayr, 19°34′S, 147°27′E, 10 Jan 1973, V. Salanitri, QM S28786; 1 ma., Mount Tregaskis, 3 km NNE, 19°15′S, 145°29′E, open forest, flight intercept trap, 17 Dec 2006–15 Feb 2007, G. Monteith, D. Cook, QM S76595; 1 fem., Bundaberg Forest, 24°52′S, 152°21′E, 1986, E. Zillman, QM S14629; 1 ma., Currumbin, 28°12′S, 153°24′E, 11 Jan 1980, D. Seeton, QM S14633; 1 fem., Eureka Ck, 17°09′S, 144°59′E, 2 Feb 1972, N. Clyde Coleman, QM S14634; 1 ma., Lords Table plateau, site 2, 22°39′S, 148°01′E, eucalypt woodland, flight intercept trap, 10 Jan–7 Mar 2006, C.J. Burwell, QM S80271; 1 fem., Brisbane, 27°28′S, 153°01′E, 16 Mar 1986, W. McKenzie, QM S14630; 2 fem., Peak Downs, 22°15′S, 148°11′E, 30 Nov 1973, V.E. Davies, QM S14631; 1 ma., 1 fem., Doboy Ck, Brisbane, 27°28′S, 153°01′E, 9 Jan 1979, D. Seeton, QM S14632; 1 ma., Lords Table, SE base, site 2, 22°40′S, 148°01′E, eucalypt woodland, malaise trap, 13 Jan–4 Mar 2006, C.J. Burwell, QM S79513; 1 ma., 1 fem., Lords Table, SE base, site 2, 22°40′S, 148°01′E, eucalypt woodland, flight intercept trap, 13 Jan–4 Mar 2006, C.J. Burwell, QM S80251; 1 ma., Bald Hills, Brisbane, 27°19′S, 153°01′E, 10 Jan 1980, D. Seeton, QM S14639; 1 fem., 1 juv., Coomburragee, Jan 2006, R.J. Raven, QM S22591; 1 ma., Proserpine, Thompson Ck, site XY18a, 20°31′S, 148°33′E, closed forest, pitfall, 14 Feb–12 Mar 2008, R.J. Raven, QM S85431; 1 fem., Bald Hills, Brisbane, 27°19′S, 153°01′E, 18–20 Dec 1979, D. Seeton, QM S14636; 1 ma., Newry Is. NP, 20°51′S, 148°55′E, 14 Feb 1975, K. McDonald, QM S14638; 1 fem., Cape Hillsborough NP, 20°55′S, 149°03′E, rainforest, 5 Jan 1975, K. McDonald, QM S14643; 1 ma., Weipa, 12°39′S, 141°53′E, 7 Feb 1975, R. Raven, V. Davies, QM S14641; 4 ma., Lords Table plateau, site 1, 22°39′S, 148°01′E, eucalypt woodland, flight intercept trap, 10 Jan–10 Mar 2006, C.J. Burwell, QM S80228; 1 fem., Homevale, 21°24′S, 148°33′E, semi-evergreen vine thicket, 1–7 Apr 1975, R. Monroe, QM S14644; 1 ma., Mazeppa NP, N end, 22°14′S, 147°15′E, brigalow, flight intercept trap, 18 Dec 2000–26 Mar 2001, D. Cook, G. Monteith, QM S55916; 1 ma., Kalbar, 3 km W, 27°57′S, 152°38′E, flight intercept trap, 2 Dec 2000–7 May 2001, C.J. Burwell, QM S55922.

Description. Male, QM S85431. Carapace 2.81 long, 2.19 wide. Abdomen 5.63 long, 1.44 wide. Total, 8.4.

I: 2.21, 0.64, 2.00, 2.00, 0.78, 7.63. II: 1.82, 0.64, 1.25, 1.68, 0.61, 6.00. III: 1.32, 0.53, 1.00, 1.21, 0.53, 4.59. IV: 2.11, 0.68, 1.75, 1.93, 0.61, 7.08. Palp: 0.89, 0.28, 0.28, 1.00, –, 2.45.

Colour. Uniform pile of short dark hairs on caput with narrow mid-line and wider bands from eye region of white hair (see Fig. 75a). Dark medial band of black hair and narrow glabrous zones with light coloured sides. *Eyes.* Group width/headwidth=0.59 through PLE, 0.48 through mid-eye group. OQ front, back, long: 40: 56: 45. MOQ front, back, long: 20: 26: 26. AME: ALE: PME: PLE, 9: 6: 9: 9. Back eye row in two lines widely separated from above, AER recurved. *Spines.* Tibia I with 3 longer ventral pairs (*ca.* 25% of tibia long), slightly overlapping and one shorter distal pair. Metarsus I, II ventrally with proximal pair longer, paired middle pair staggered, and short distal pair. I: fe p4d3r4; pa p1w, d1 distal, r1; ti p2d2r2v.2.2.2+2; me p3r3v2.2.2. II: fe p4d2r4; pa p0d1 distal r1; rest as I. III, IV: p5d2r5; pa d1r1; ti as I but spines shorter. Palp: fe p1d1.2; pa p1w, 1 distal d very long; ti, p2d1 very long. Palp. Cymbial edge with two spine-like bristles prolaterally and 1 retrolateral; 2 long ventrally on cymbial cone. Tibia slightly longer than patella, tibia with small retrolateral notch distally and wide

rectangular ventral plate; long irregular conical RTA; cymbial cone long, distally flattens with concavity extending as far forward again as bulb insertion; subtegulum large with internal scalloping; embolus long (Fig. 76a).

Female QM S22591. As for male but: Carapace 3.46 long, 2.59 wide. Abdomen 5.95 long, 2.05 wide. Total, 9.4.

I: 4.98, 1.46, 4.93, 4.68, 2.34, 18.39. II: 5.12, 1.46, 4.98, 5.12, 2.34, 19.02. III: 3.85, 1.07, 3.12, 3.56, 1.37, 12.98. IV: 5.17, 0.24, 4.29, 5.27, 1.76, 16.73. Palp: 1.46, 0.54, 0.93, –, 1.22, 4.15.

Group width/headwidth=0.62 through PLE, 0.50 through mid-eye group. AME to clypeus 0.24. From above, AER straight; AME slightly larger than ALE but equidistant. PER in two lines. Eye region quite flat. Caput flat. *Spines.* I, II: fe p5d3r5; pa d1 distal; ti p2r2v.2.2.2; me p2r2v2.2.2. III: p5d3r5; pa d1; ti p2s1r2v2.2.2; me p3r3v1.1.1.1. IV: fe p5d3r0.0.3; pa d1; ti p3d1r3v2.2.2; me p2r2v1.1.1.1. Palp: fe p1d1.1; pa 1 distal d; ti, d2r21; ta p1r1.Epigyne (Fig. 76c, d). Anterior ridge forms cordate cavity; internally, large flared translucent duct doubles back to spermatheca. Posterior coils evident ventrally, but not dorsally.

Distribution. Australian Region– Australia (eastern Queensland, Western Australia, New Guinea (Papua New Guinea); Oriental Region–Myanmar, India, Philippines, Thailand, Singapore; Palaearctic Region–Japan. Davies (1985) listed only *Perenethis venusta* from Australia. Volker Framenau (pers. comm.) reported a specimen from the Kimberley Ranges, Western Australia.

Remarks. The type of *Perenethis unifasciatus* Doleschall, 1859 should be in RMNH, Leiden, but Chrysanthus (1967) was unable to find it because, as Sierwald (1997) reports, it was never received. Doleschall's figures are only of the habitus not of the critical palp. Further, although the cataloguers, Bonnet and Roewer, considered *P. venusta* and P. *unifasciatus* as synonyms, Chrysanthus (1967) found further material of both and concluded the species were distinct. But Sierwald (1997) rejected Chrysanthus and that is followed here.

The palp of the holotype male (examined) of *Dolomedes stilatus* Karsch, 1878 is the same as the eastern Australian material and the holotype of *P. venusta.* The male palp of the holotype of *Perenethis kawangisa* Barrion & Litsinger, 1995 is well illustrated and concurs completely with that of *P. venusta.*

Hygropoda Thorell, 1895

Hygropoda Thorell, 1895: 221; Silva, 2013b: 290. Type species, *Tegenaria dolomedes* Doleschall, 1859 by subsequent designation of Simon (1903: 316).

Diagnosis. Males and females are very distinctive in the pseudosegmented (curved) tarsi in combination with the small size and, in Australia at least, green colour in life.

Description. Carapace profile flat. Clypeus steep to vertical; eyes subequal but clearly ALE are smallest. Carapace with subtle short "shoulder". Legs very long (Fig. 7e); tarsi of males and females curving, pseudosegmented (Fig. 7e). Carapace in lateral view with slight medial saddle rising to eye region (Fig. 5h). PTF present (Fig. 6b). Eyes of PER clearly larger than those of AER; AER *ca.* 0.7 of width of PER (Fig. 4h). Males and females of similar size. Aboreal diurnal and nocturnal spiders hunting on small sheet web over leaves in rainforest (*H. lineata*). Female tarsi distally incrassate for distal 0.25 and bent at midpoint. Trochanters with shallow notches. Palpal femur (male) subequal to carapace length. Male palp in the Pisaurinae form.

Distribution. Central African Republic, Madagascar, South-east Asia, Australia, Venezuela, Oriental Region; SE Asia.

History. The original, apparently stylized, figure of the type species, *Tegeneria dolomedes* Doleschall, 1859, lacks the diagnostic elongate flexible tarsi considered a key diagnostic character of the genus and the type species has never been revised.

Dankittipakul *et al.* (2008) reviewed the genus *Hygropoda* in Thailand. Davies (1985) listed only *Hygropoda lineata* from Australia and, based upon her examination of the types, included *Hygropoda spuripes* Strand, 1911 in its

synonymy. Dankittipakul *et al.* (2008) admit all *Hygropoda* have long flexible tarsi with the AER recurved and much narrower than PER.

Of the 28 species of *Hygropoda* lised in the WSC (2017), 16 (including the type species) have not been revised morphologically in the past 100 years; the figures of those, if they were provided, are inadequate to recognise the species. Dankittipakul, Singtripop & Zhang (2008) reviewed the genus in Thailand and found the fauna were all species described from China by Zhang, Zhu & Song (2004). The *Hygropoda* figured here is historically taken to be be *H. lineata* with which it is clearly conspecific. However, given that these are widespread species, the Malaysian *H. longimana* (Stoliczka, 1869), the Sulawesian *H. longitarsis* (Thorell, 1877) and *H. longitarsis fasciata* (Thorell, 1877), *H. albolimbata* (Thorell, 1878) are geographically possible conspecifics and all compete with *H. lineata* for seniority.

Hygropoda lineata (Thorell, 1881)

(Figs 4h, 5h, 6b, 7e, 77, 78a, b, 79a–c. Map 6c)

Dendrolycosa lineata Thorell, 1881: 366.

Hygropoda spuripes Strand, 1911: 69. First synonymised by Davies, 1985: 103.

Hygropoda exilis Thorell, 1881: 369, penult. male, "Dorei Hum (N. Guinea)", coll. O. Beccari, 1875, MCSN, examined. New synonymy.

Material examined. Queensland: holotype (*Dendrolycosa lineata*), female, Somerset, Cape York, coll. L. M. D'Albertis, 1875, MCSN, examined. Indonesia: holotype (*Hygropoda spuripes*), female, Wokam, Aru Is., fem. (missing from SMF, not examined), paratype(s) SMF ma. adult (missing, not examined, 16197); holotype (*Hygropoda exilis*) penult. male, "Dorei Hum (N. Guinea)", coll. O. Beccari, 1875, MCSN, examined.

Other material examined. Queensland: 1 fem., Lake Placid, 16°55'S, 145°46'E, rainforest, night collection, 12 Jun 1987, R.R. Jackson, QM S7115; 1 ma., Windsor Tableland, 1.2 km past barracks, 16°15'S, 145°02'E, rainforest, 8 Feb 1998, G. Monteith, D. Cook, QM S54006; 1 fem., Lake Boronto (=Wincheura), Newcastle Bay, rainforest, 30 Jan–4 Feb 1975, G. Monteith, QM S28851; 2 fem., Lake Placid, 16°55'S, 145°46'E, rainforest, night collection, May 1987, R.R. Jackson, QM S7116; 1 ma., Topaz, PEI Road, Frith house, 17°24'S, 145°41'E, rainforest, flight intercept trap, 6 Dec 1993–25 Feb 1994, G. Monteith, H. Janetzki, D. Cook, QM S58026; 1 ma., 1 juv., Massey Ra., 2nd camp, 17°14'S, 145°48'E, hand collection, 11–12 Oct 1991, G. Monteith, H. Janetzki, D. Cook, QM S58621; 2 fem., Lockerbie Scrub, Cape York, 10°48'S, 142°28'E, rainforest, 19–22 Apr 1973, G. Monteith, QM S14659; 1 ma., Paluma Dam Road site 1, 18°56'S, 146°10'E, flight intercept trap, 8 Dec 1990–5 Feb 1991, G.B. Monteith, Seymour, QM S58002; 1 fem., Lockerbie, Cape York, 10°48'S, 142°27'E, 30 Jan 1975, R.J. Raven, QM S28853; 3 fem., Prince of Wales Is., 10°41'S, 142°09'E, closed forest, 13 Feb 1975, E. Cameron, QM S28852; 4 fem., Amphitheatre–Crystal Falls, Nitmiluk NP, rainforest, 16 Mar 1995–17 Mar 1995, G. Monteith H.Janetzki, QM S37894; 1 fem., West Claudie R, Iron Ra., 12°45'S, 143°14'E, rainforest, 3–10 Dec 1985, G. Monteith, D. Cook, QM S39458; 1 ma., Mission Beach (S3), 17°56'S, 146°04'E, rainforest, malaise trap, 29 Jan–4 Mar 1996, M. Cermak, QM S39128; 3 fem., Shiptons Flat, 15°48'S, 145°15'E, road verge, 17 Nov 1975, V. Davies, R. Monroe, QM S51189. Northern Territory: 1 fem., Fish River, 14.1025°S, 130.7847°E, 24 Apr 2012, R. Raven, QMS. Solomon Islands: 1 fem., New Georgia; Javae, near Seghe below campsite, rainforest, 24 Jun 1990, T. B. Churchill, QM S42972.

Juveniles given only with locality, coordinates and registration number: Queensland: Cape Tribulation, 16°05'S, 145°26'E, QM S14017; Prince of Wales Is., Torres Strait, 10°41'S, 142°09'E, QM S28850; Richardson's Property, Bellenden Ker, 17°16'S, 145°57'E, QM S26260; Cape Tribulation, N of Pilgrim Sands, 16°05'S, 145°26'E, QM S14062; Bamaga, 10°53'S, 142°24'E, QM S12492; Bellenden Ker Ra., Cableway Base Station, 17°16'S, 145°54'E, QM S27828.

Diagnosis. Small spiders, green in life (Fig. 77), with almost glabrous carapace. The male palp (Fig. 78a, b) is very similar to those of *Dolomedes* but lacks the retroproximal cymbial flange and the distal prolateral and ventral processes on the male palpal tibia. The spination is always erect, as in the Oxyopidae.

Description. Male Gordonvale 1 Mar 1972, NC Coleman, QM S. Carapace 3.53 long, 2.94 wide. Abdomen 5.06 long, 1.76 wide. Total, 8.6.

I: 8.24; 1.76; 8.12; 8.00; 5.53; 31.65. II: 8.12; 1.65; 7.53; 7.41; 4.71; 29.41. III: 6.71; 0.12; 5.41; 5.76; 4.12; 22.12. IV: 7.88; 1.65; 6.94; 7.65; 4.71; 28.82. Palp: 3.29; 0.94; 1.18; 1.53; 6.94.

Eyes. Group width/headwidth=0.68 through PLE, 0.64 through mid-eye group. OQ front, back, long, 31: 38: 25. MOQ front, back, long, 16:20:16. AME–AME, 3; AME–ALE, 2; PME–PME, 4; PME–PLE, 8. AME: ALE: PME: PLE, 7: 6: 7: 8. Back eye row in one recurved line, back edge of PME on line of front edge of PLE; from above, AER recurved. *Spines.* Only distal spines on femora strong.

Legs I, II: fe p2–3d2–4r3–4; pa p1 distal 1, r1w; ti p2d2r2v.2.2.2.2; me p2r2v2.2. Leg III: fe p5d3r3, pa p1d1 (distal) ; ti p2d2r2v.2.2.2; me p2r2 v2.2.2.2 + distal whorl of 4. Leg IV, as II but fe p3de3r0–2. Palp: fe p1d1.1r1; pa d1; ti p2d1r1. Tarsi strongly curved, pseudosegmented, slender, similar width for length. Palp (Figs 7e, 78a, b). Tibia only slightly longer (1.10) times longer than patella. RTA stalked and deeply incised with ventral process distally bifid; median apophysis small; DTP rectanguloid; cymbial cone long, slender.

Female QMS. Carapace 2.94 long, 2.59 wide. Abdomen 5.88 long, 2.47 wide. Total, 8.8.

I: 5.76; 1.65; 7.65; 5.76; 3.53; 24.35. II: 5.29; 1.41; 5.06; 4.71; 3.41; 19.88. III: 4.82; 0.94; 3.76; 3.41; 2.47; 15.41. IV: 5.53; 1.06; 4.12; 4.71; 3.18; 18.59. Palp: 2.00; 0.82; 1.18; 1.18; 5.18.

Colour. Pallid, faded. Fine bands of white hair on carapace from PLE to fovea, medial short and long submargin. Tibiae I, II bent at distal half to third. Spines like male but longer on patellae–tibiae longer and stronger than on femora. Palp: fe p1d1.1r0; pa p1 distal 1; tibia p1r1. Epigyne. Very subtle: two long bracket like ridges; internally appear simple (Fig. 79b, c).

Distribution and habitat. Rainforest and riverine closed forest in the Northern Territory and northern Queensland to just north of Townsville.

Biology. Bright greeen in life (Fig. 77), these spiders build small "sheet" hunting webs entirely on leaves and are both diurnal and nocturnal. The webs are not sheets but the sparse strands line in one plane.

Remarks. As a penultimate male, the holotype of *H. exilis* cannot be recognised with certainty as distinct from *H. lineata* and it is thus placed in synonymy.

Inola Davies, 1982

Inola Davies, 1982: 479. Type species, *Inola amicabilis* Davies, 1982 by original designation.

Diagnosis. Differs from *Dendrolycosa*, the other extensive sheet-web building pisaurid in Australia, by the ALE being as large if not larger than the PME (Figs 80c, 82c), rather than the usual condition of being the smallest eyes. Differs from *Hygropoda* in lacking pseudosegmented tarsi.

Description. Carapace in lateral view with slight medial saddle rising to eye region (as in *Dendrolycosa*). Pretarsal fracture present (Davies, 1982, plate 1, fig. 17). ALE as big as PLE; AER almost as wide (0.9) as PER (Figs 80c, 82c). Males and females of similar size.

Included species. *Inola amicabilis* Davies, 1982, *Inola cracentis* Davies, 1982, *Inola subtilis* Davies, 1982, *Inola daviesae* Tio & Humphrey, 2010.

Distribution, habitat and web. *Inola* is known only from rainforests in north-eastern Queensland. The spiders build a sheet web in trees and scrubs; the web becomes funnel-shaped and wraps around a stem near the retreat which is 2–3 cm long. The web is similar to that of *Dendrolycosa* (Fig. 72b).

Remarks. Davies (1982) was a complete revision and only a minimal treatment is given.

Inola amicabilis Davies, 1982

(Figs 4b, 80a–e, 81a, b, 82a–c. Map 6d)

Inola amicabilis Davies, 1982: 479.

Material examined. Types. Queensland: holotype, QM S860; female paratypes QM S861; 1 m 3 males, QM S864–8, fem., QM S870–1 ma.; QM S872, 4 ma., 5 fem.; QM S873, ma.

Distribution & habitat. Wet Tropics World Heritage area, Queensland, at Cooktown and just south at Home Rule.

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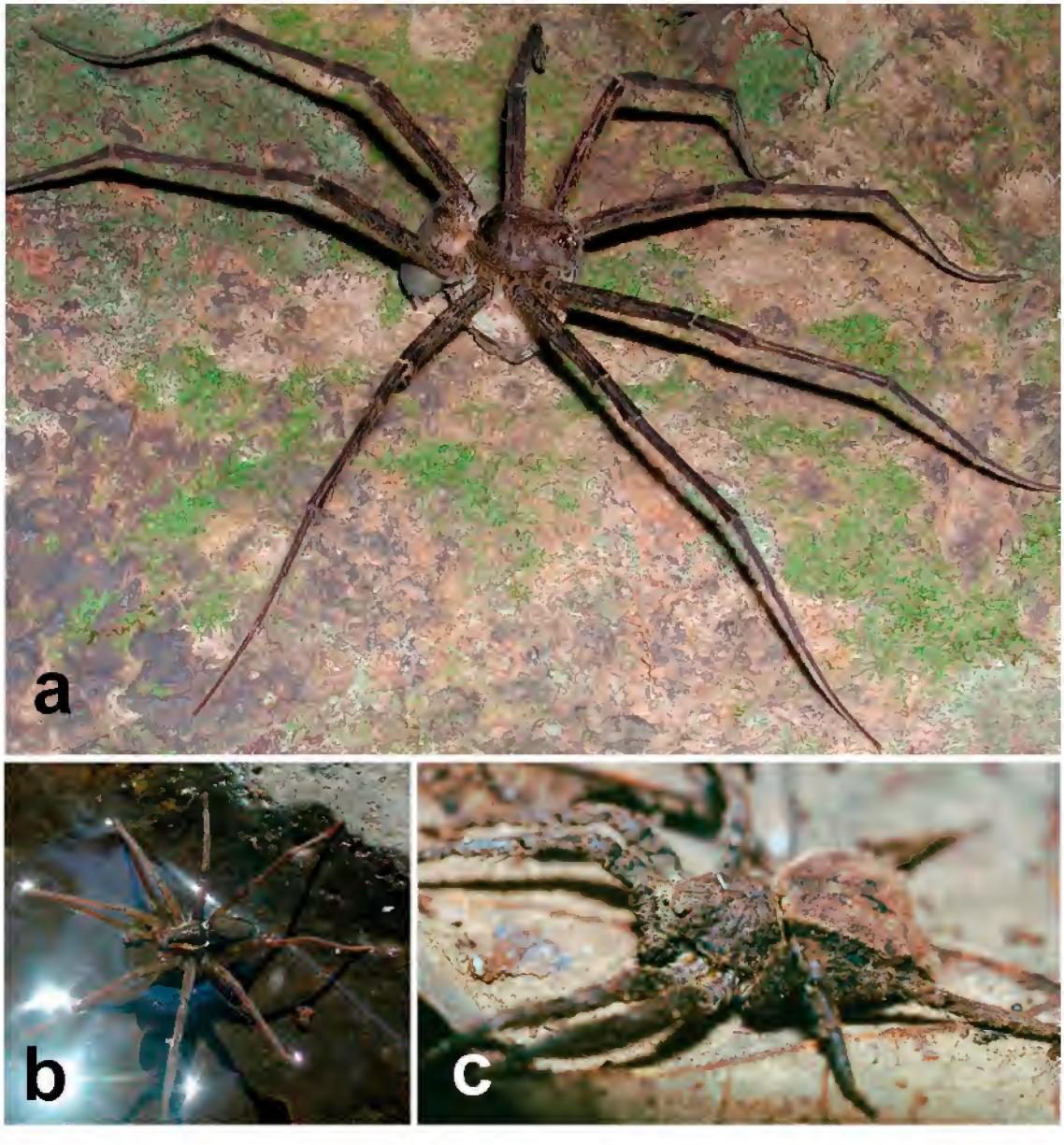


FIG. 1. Habitus, dorsal views. **a,** *Megadolomedes trux* (Lamb, 1911), female; **b,** *Dolomedes vicque* sp. nov., female; **c,** *Bradystichus calligaster* Simon, 1880, female.

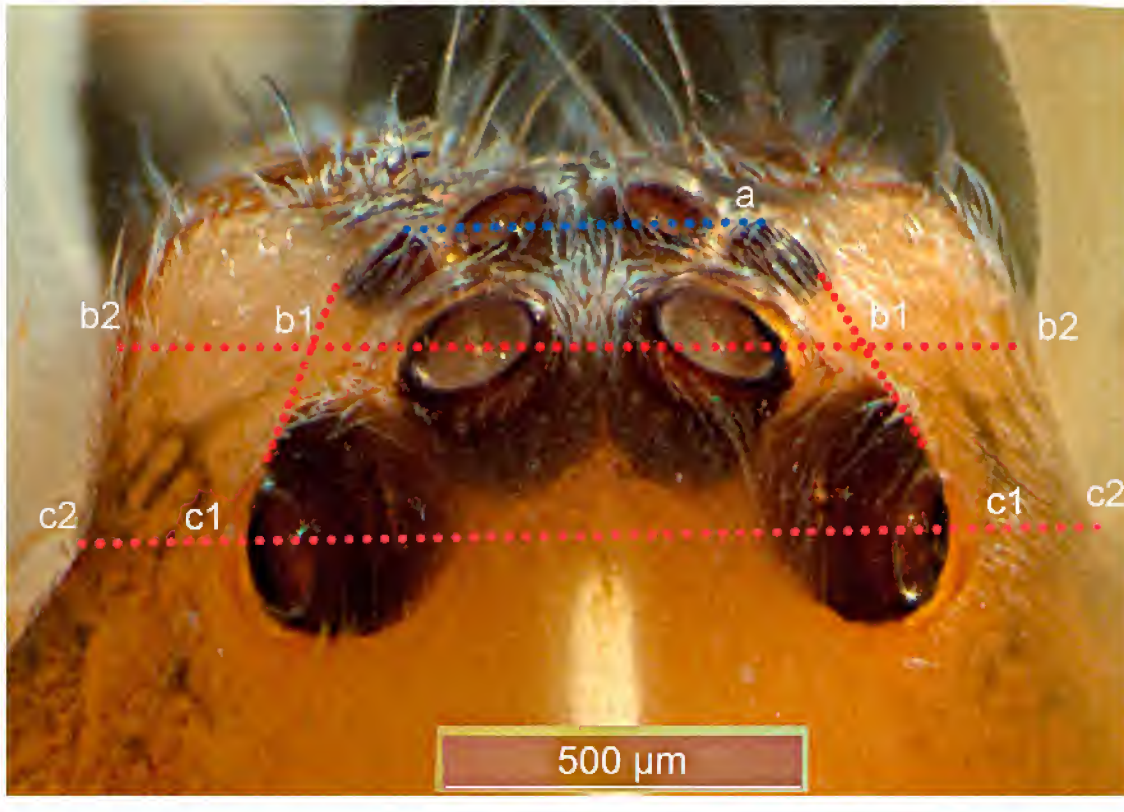


FIG. 2. Eyes of *Ornodolomedes nebulosus* sp. nov., showing measurements. **a,** percentage overlap of eyes of anterior row; **b,** width of head (b2–b2) through PME and of eye group on same line (b1–b1); width of head (c2–c2) through PLE and of back of eye group on same line (c1–c1). c2 also marks the position of "caput shoulder".

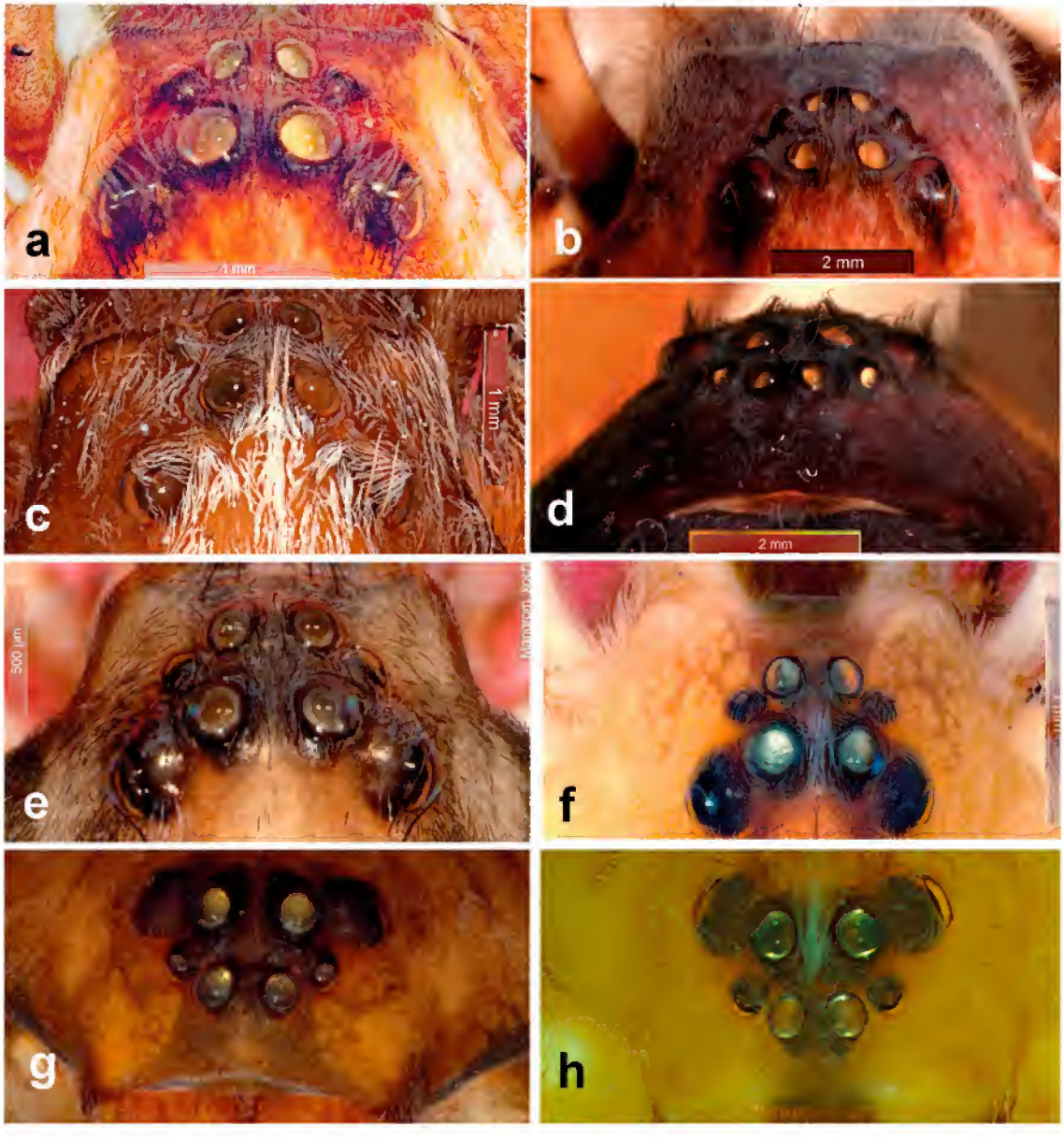


FIG. 3. Eye groups of different genera viewed from above and in front (the "face"). **a,** *Dolomedes wollemi* sp. nov., dorsal view; **b, d,** *Megadolomedes trux* (Lamb, 1911), female, **b,** dorsal view, d, "face"; c, *Bradystichus calligaster* Simon, 1880, dorsal view; e, g, *Mangromedes kochi* (Roewer, 1951). **e,** dorsal view; **g,** "face; **f, h**, *Ornodolomedes mickfanningi* sp. nov., female, QM S104681; **f,** dorsal view; **h,** "face".

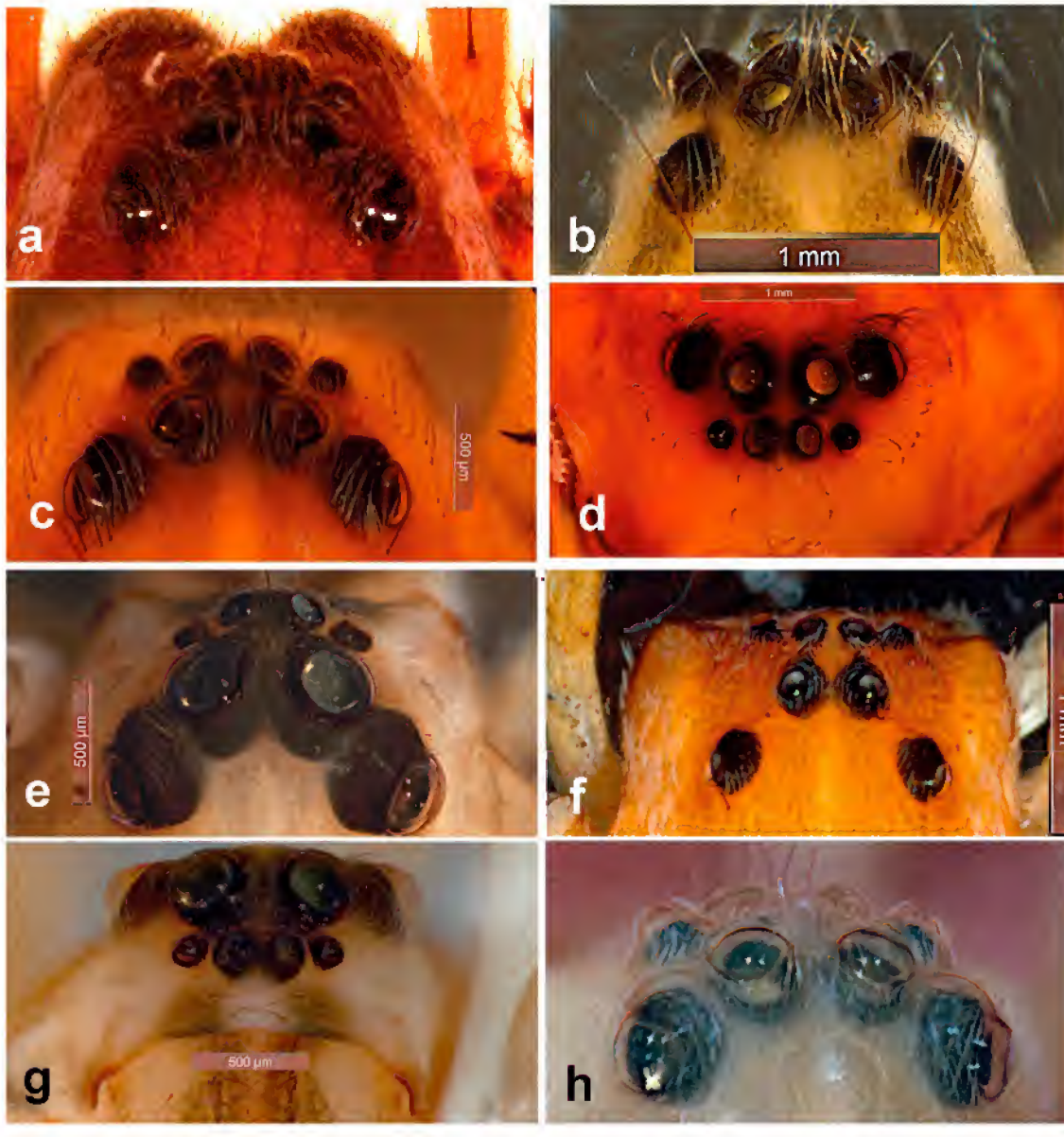


FIG. 4. Eye groups of genera viewed from above and in front (the "face"). **a,** *Tasmomedes eberhardarum* (Strand, 1913), dorsal view; **b,** *Inola amicabilis* Davies, 1982, QM S881, ma., dorsal view; **c, d,** *Dolomedes facetus* L. Koch, 1873, QM S107111, male, dorsal (c) and "face" (d). **e, g,** *Caledomedes flavovittatus* (Simon, 1880), **e,** dorsal view; **g,** "face"; **f,** *Perenethis venusta* L . Koch, 1878, female, QM S22591, dorsal view; **h,** *Hygropoda lineata* (Thorell, 1881), dorsal view.

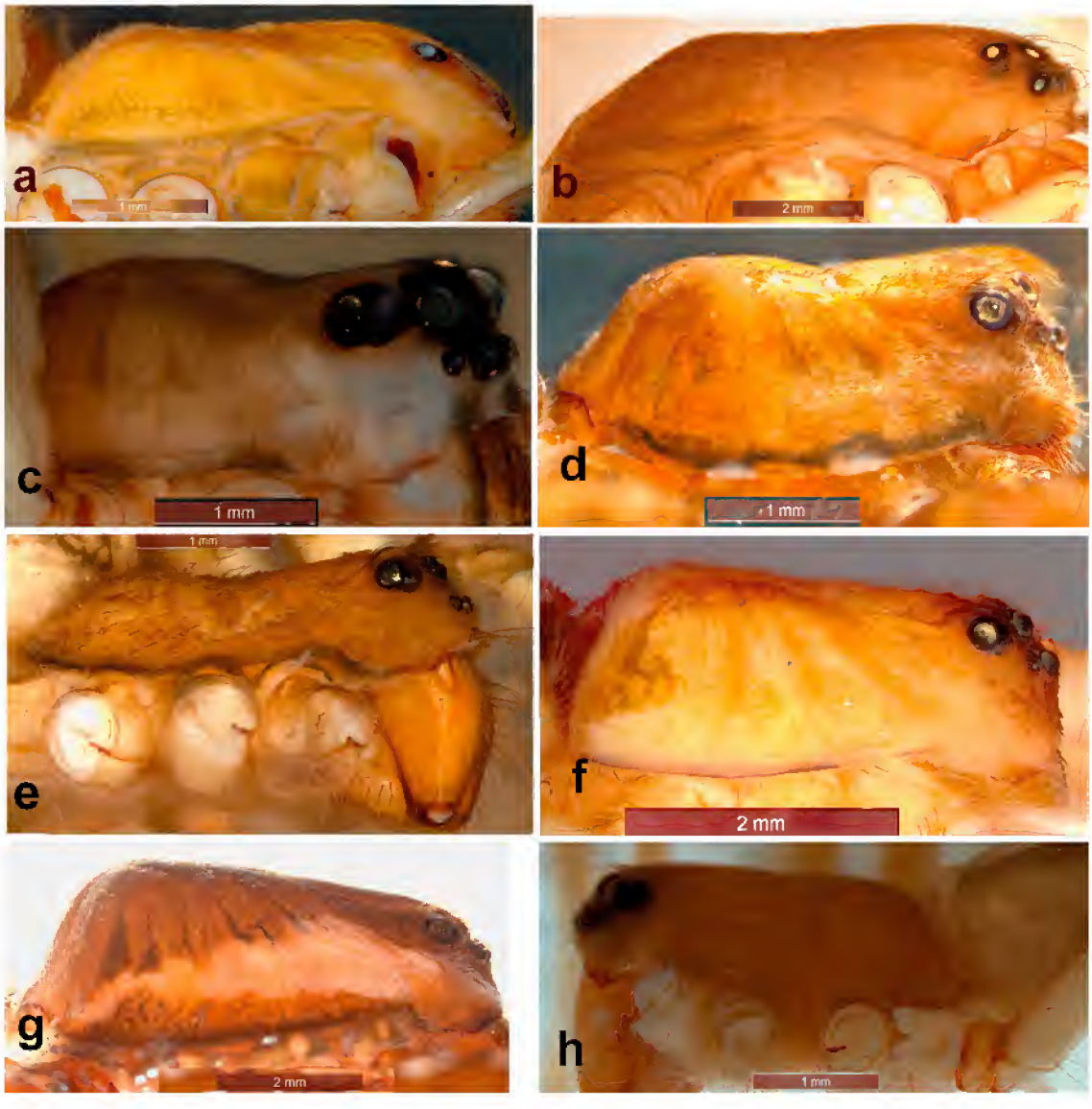


FIG. 5. Carapace, lateral view. **a,** *Perenethis venusta* L . Koch, 1878, female, QM S22591; **b,** *Dendrolycosa kakadu* sp. nov., female, QM S53981; **c,** *Caledomedes flavovittatus* (Simon, 1880); **d,** *Mangromedes kochi* (Roewer, 1951), female, QM S34613; **e,** *Ornodolomedes gorenpul* sp. nov., female, QM S55979; **f,** *Ornodolomedes mickfanningi* sp. nov., female, QM S104681; **g,** *Dolomedes albicomus*, male, QM S107110; **h,** *Hygropoda lineata* (Thorell, 1881), male, QM.

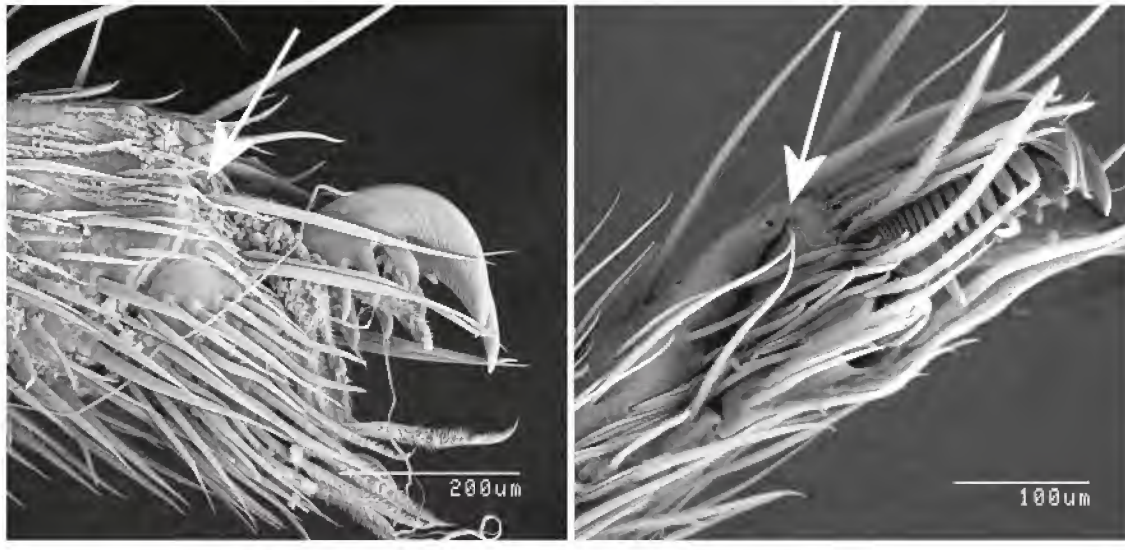


FIG. 6. Pretarsal fracture (arrows), scanning electron micrographs, lateral view. **a,** *Bradystichus*; **b,** *Hygropoda*, ventral view.

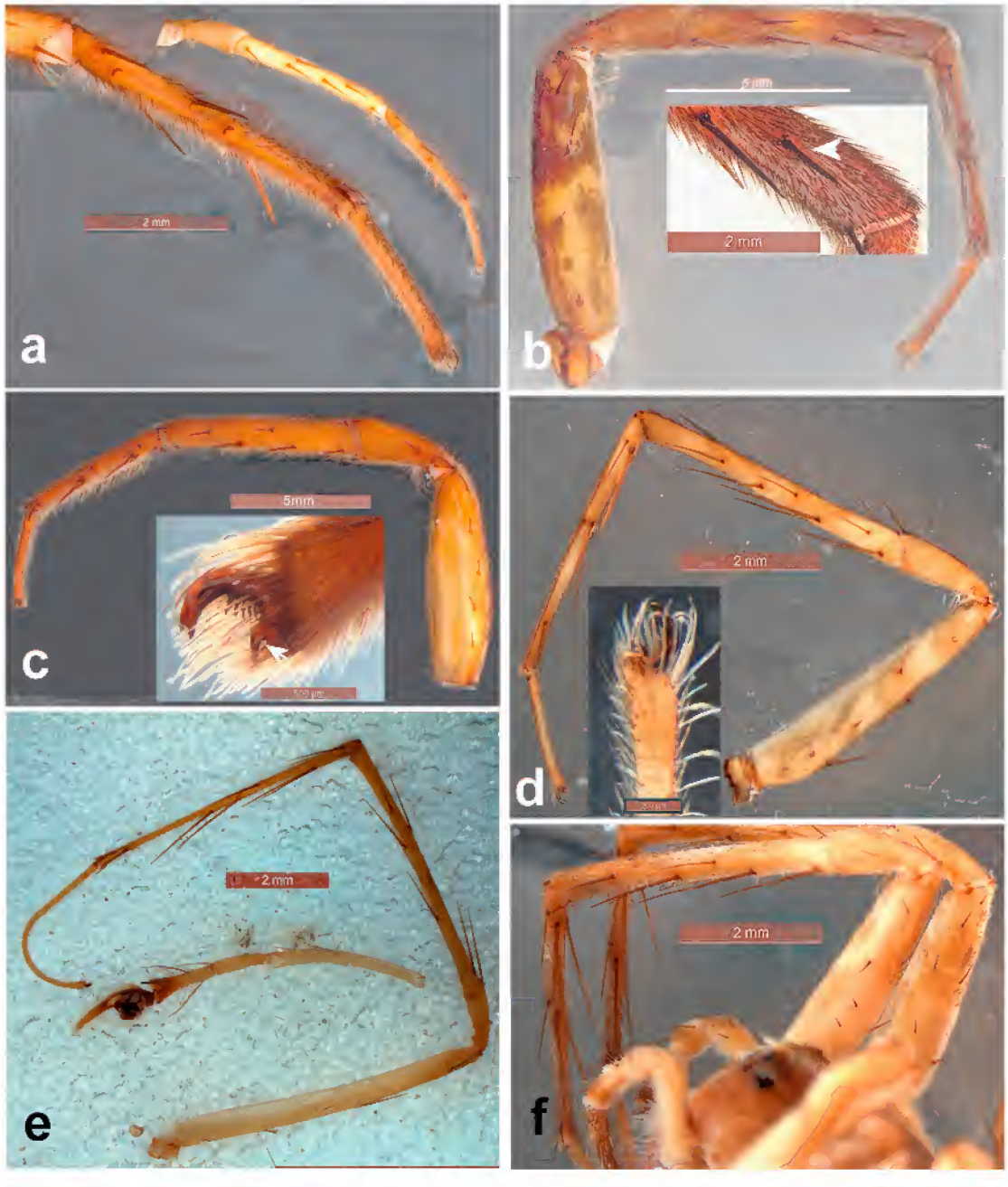


FIG. 7. Leg I, female (a–d, f), prolateral view. **a,** *Dolomedes facetus*, QM S107111; **b,** *Dolomedes mankorlod* sp. nov., inset shows tibial scopula; **c,** *Dolomedes albicomus*, QM S79214, inset shows claws with slender tooth on third claw; **d,** *Mangromedes kochi*, QM S108404, showing long tibial and metatarsal spines, inset shows claws with slender tooth on third claw; **e,** *Hygropoda lineata*, male QM S39128, shows long tibial and metatarsal spines and curved tarsi; **f,** *Ornodolomedes mickfanningi* sp. nov., QM S76373, showing long tibial and metatarsal spines.

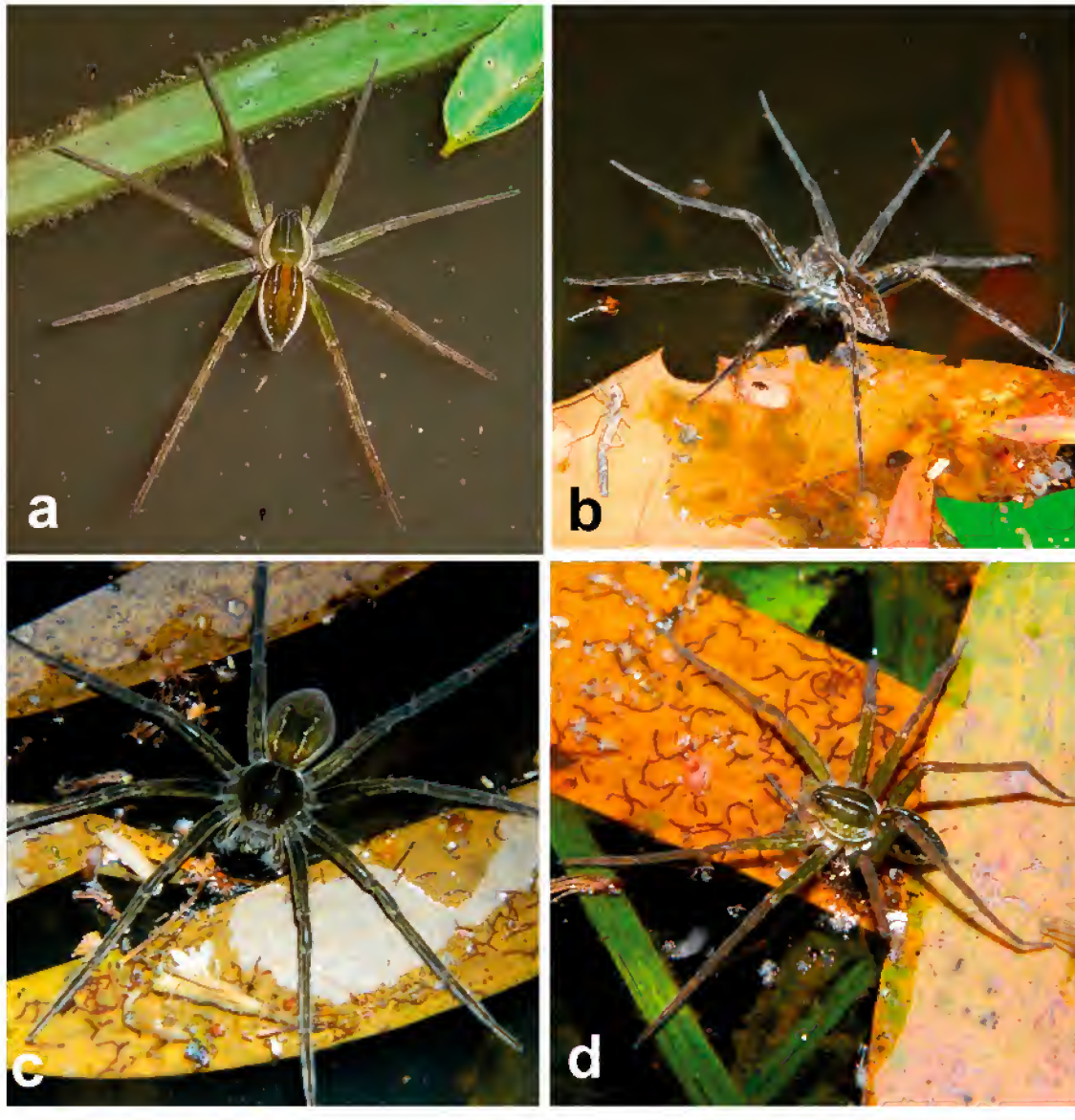


FIG. 8. *Dolomedes facetus*, habitus, dorsal view, showing pattern. **a,** female. **b–d,** Coolibah camp, Steve Irwin Wildlife Reserve, Pascoe River, north-east Queensland. **b, c,** female; **d,** male.

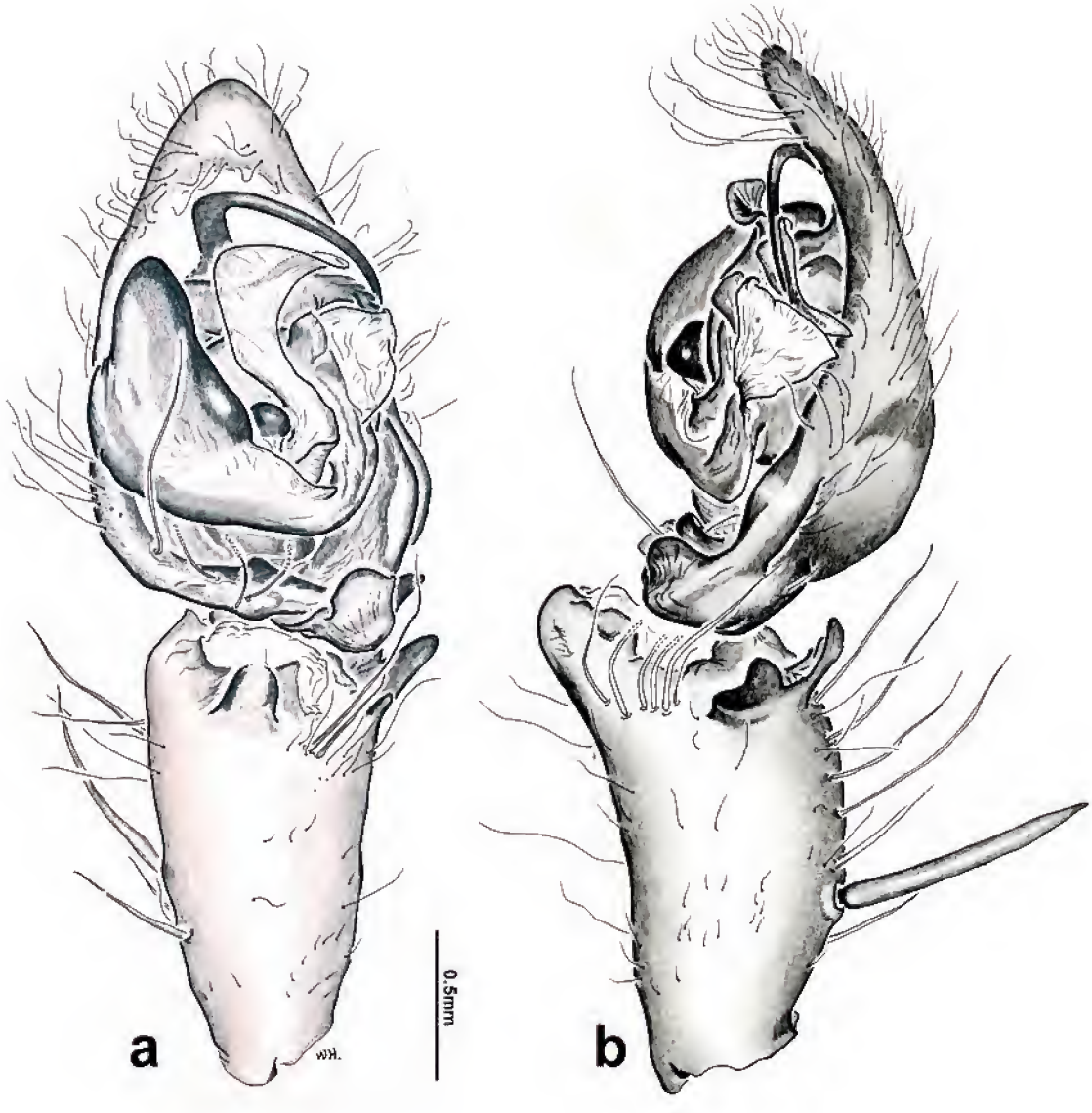


FIG. 9. *Dolomedes facetus* L. Koch, 1876, male palpal tibia and cymbium, Carnarvon, QM S107111. **a,** ventral view; **b,** retrolateral view.

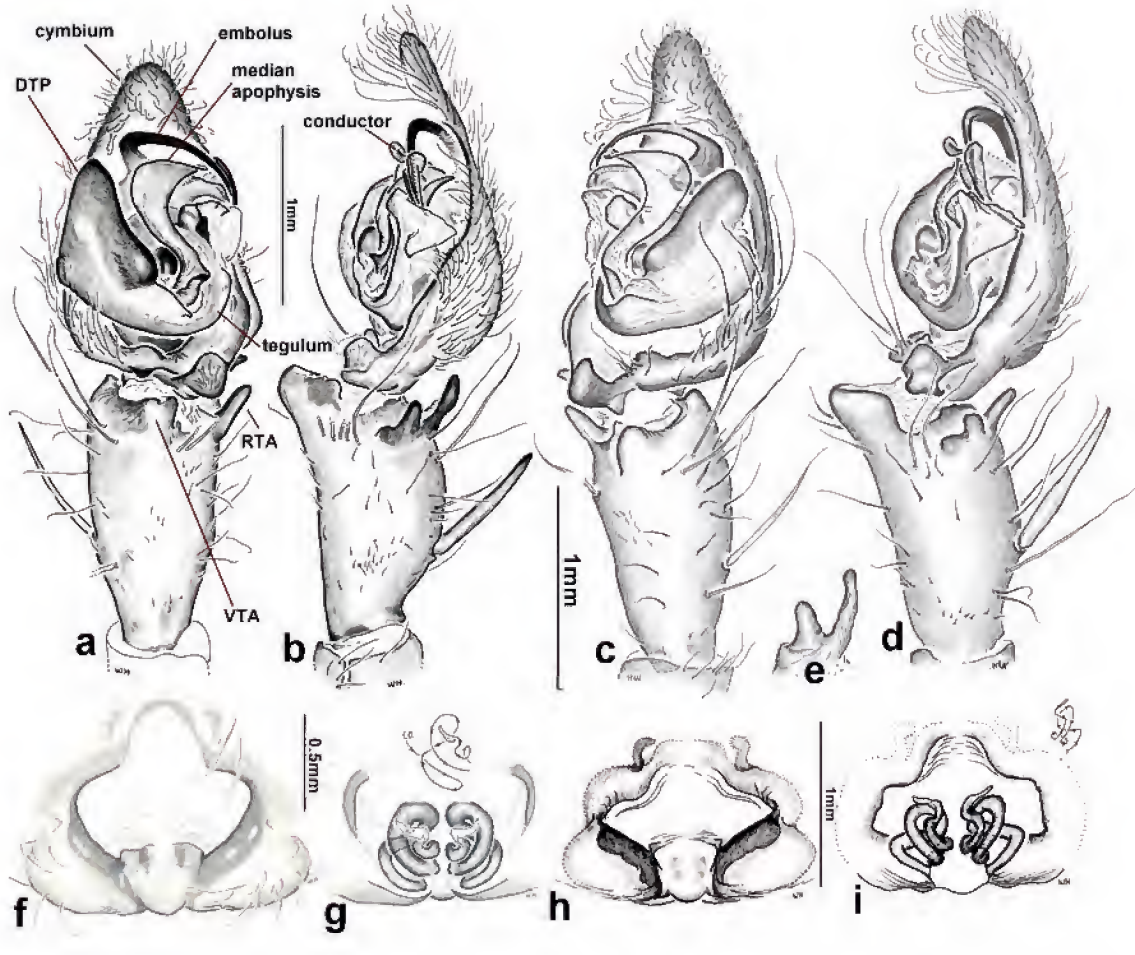


FIG. 10. Dolomedes facetus L. Koch, 1876, male palpal tibia and cymbium. **a, b,** Coolibah, QMS 104917; **a,** ventral view; **b,** retrolateral view. **c–e,** Musselbrook QM S96305, mirrored. **c,** ventral view; **d,** retrolateral view, **e,** RTAmax view. f–i, female epigyne. **f, g,** Carnarvon, QM S107111 ; **f,** external, **g,** internal; **h, i,** QM S67723; **h,** external, **i,** internal. Abbreviations: DTP, distal tegular process; VTA, ventral tibial apophysis.

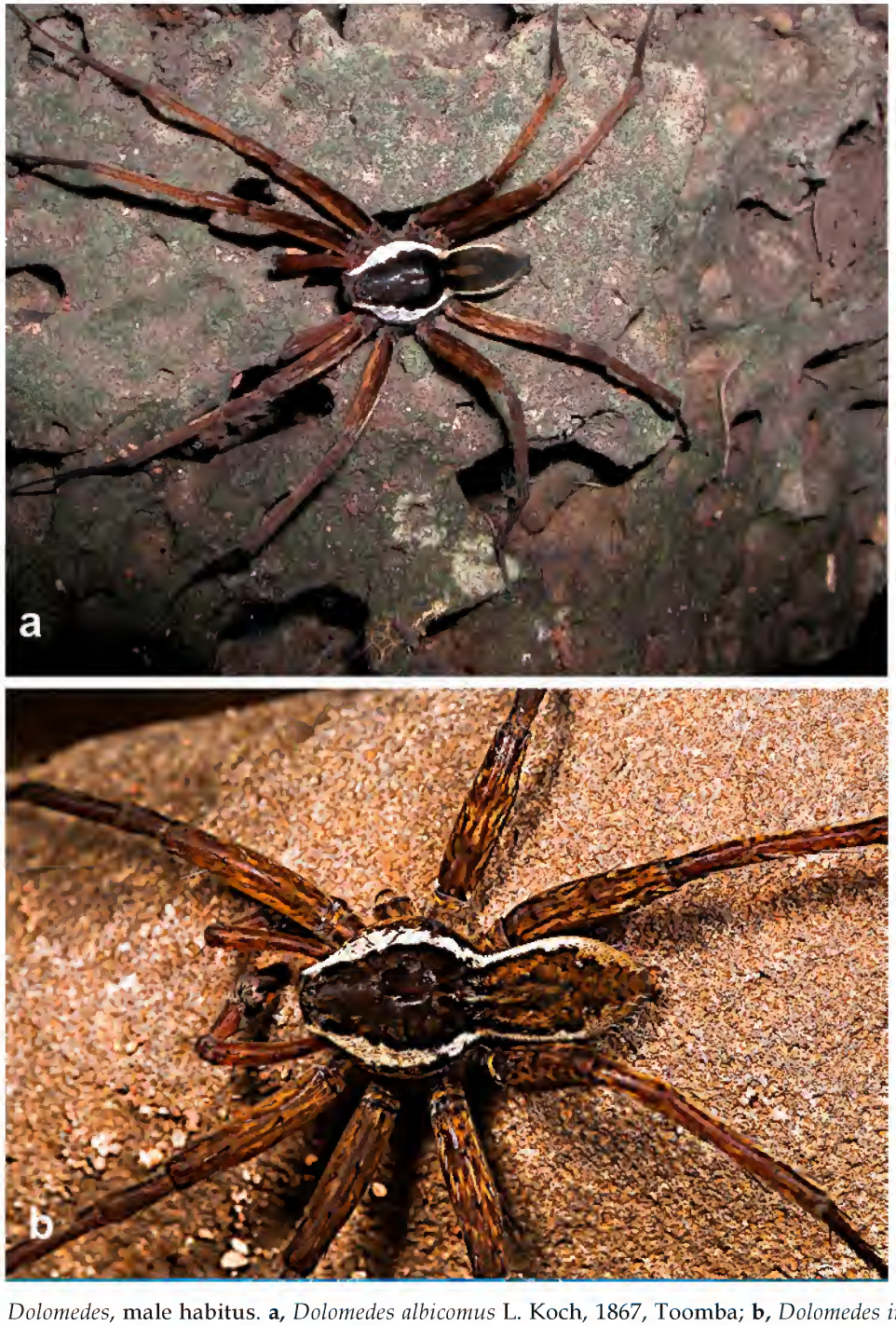


FIG. 11. *Dolomedes*, male habitus. **a**, *Dolomedes albicomus* L. Koch, 1867, Toomba; **b**, *Dolomedes instabilis* L. Koch, 1876, Avon River, Victoria, image, V. Framenau.

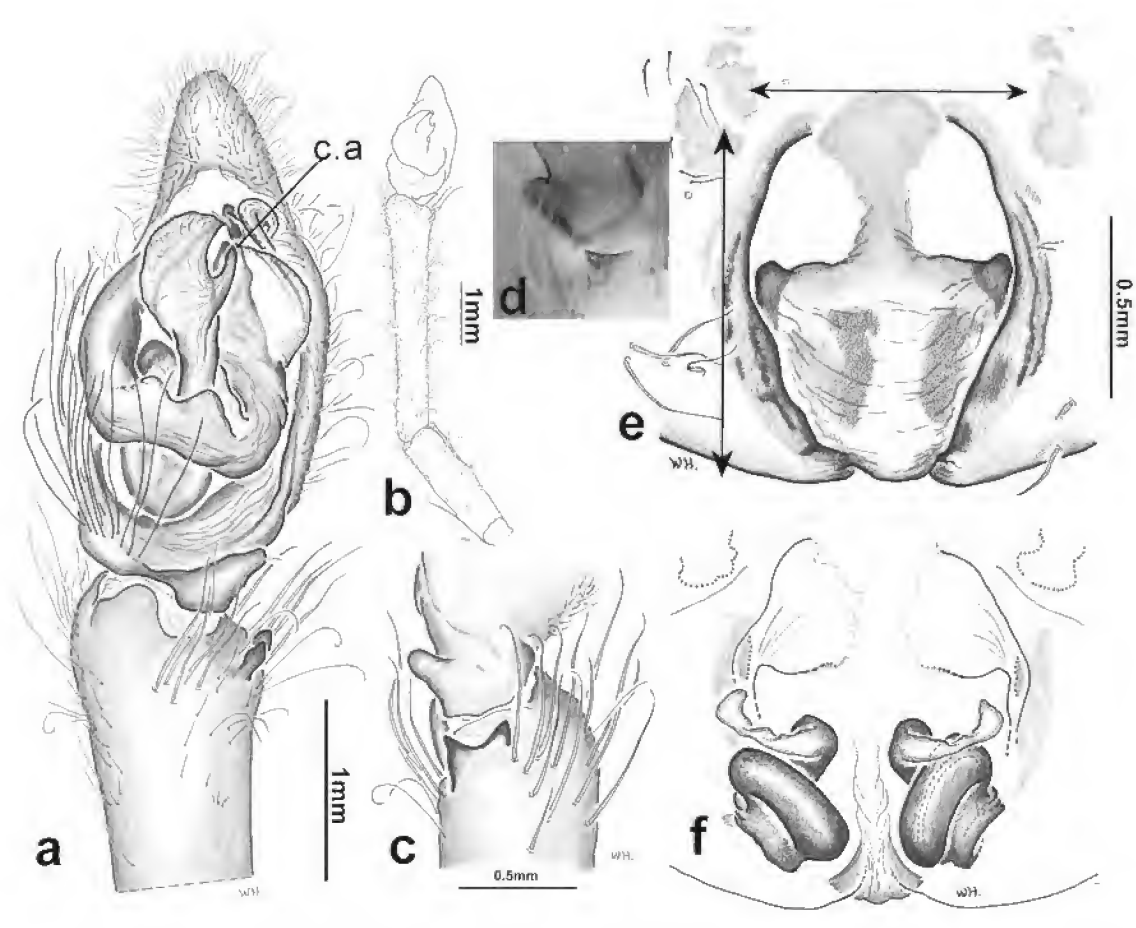


FIG. 12. *Dolomedes albicomus* L. Koch, 1867. **a–c,** male palpal patella, tibia and cymbium, QM S28795, Ayr. **a,** ventral view showing chelate apophysis (c.a); **b,** male palpal patella to cymbium. **c,** retrolateral view; **d,** holotype (ZMH), RTA and cymbium, retrolateral view. **e, f,** female epigyne, QM S79214. **e,** external showing length and width of epigyne as used herein, f, internal view.

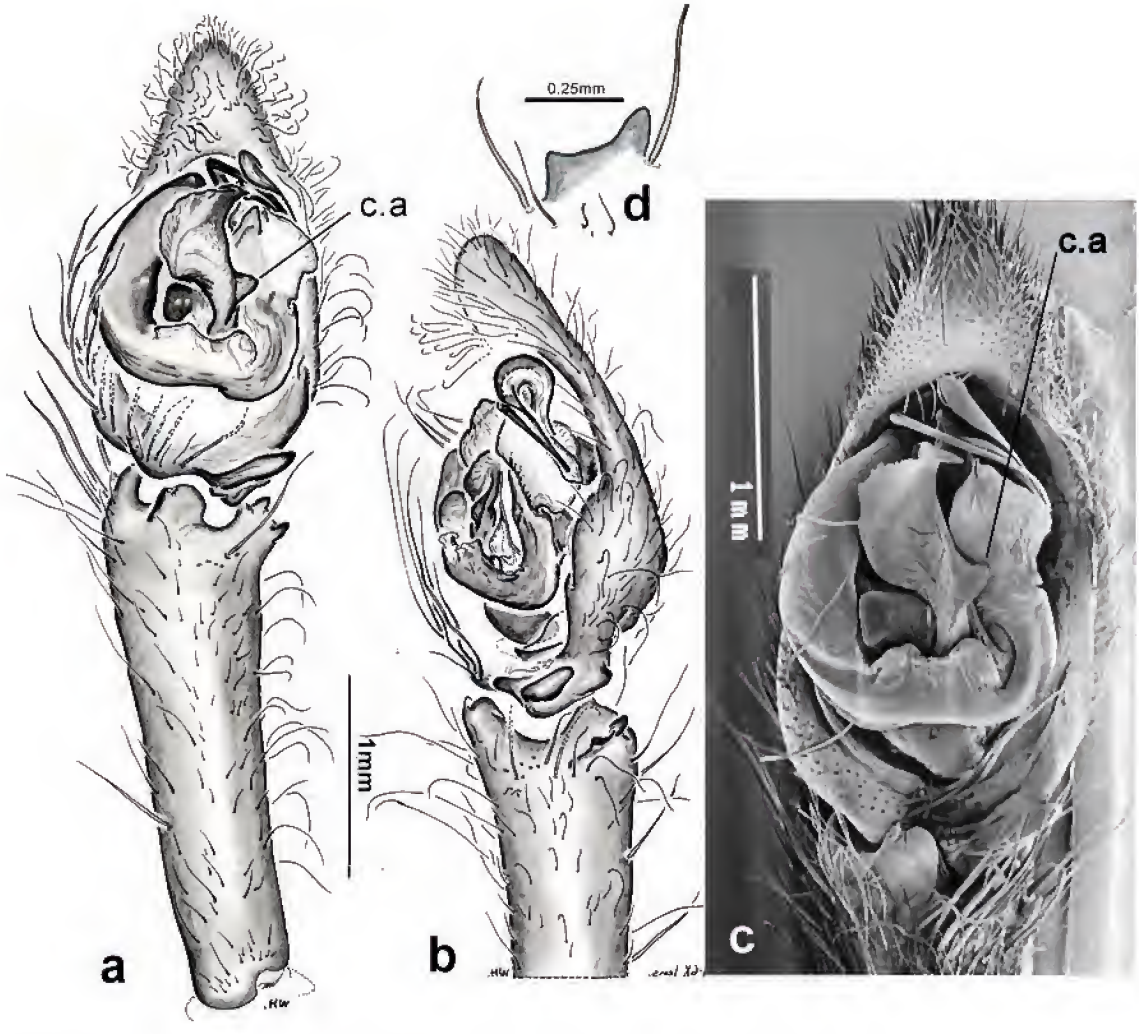


FIG. 13. *Dolomedes instabilis* L. Koch, 1876, male palpal tibia and cymbium, Boggomoss, QM S37350. **a, c,** ventral view showing chelate apophysis (c.a); **b,** retrolateral view; d, RTA max view.

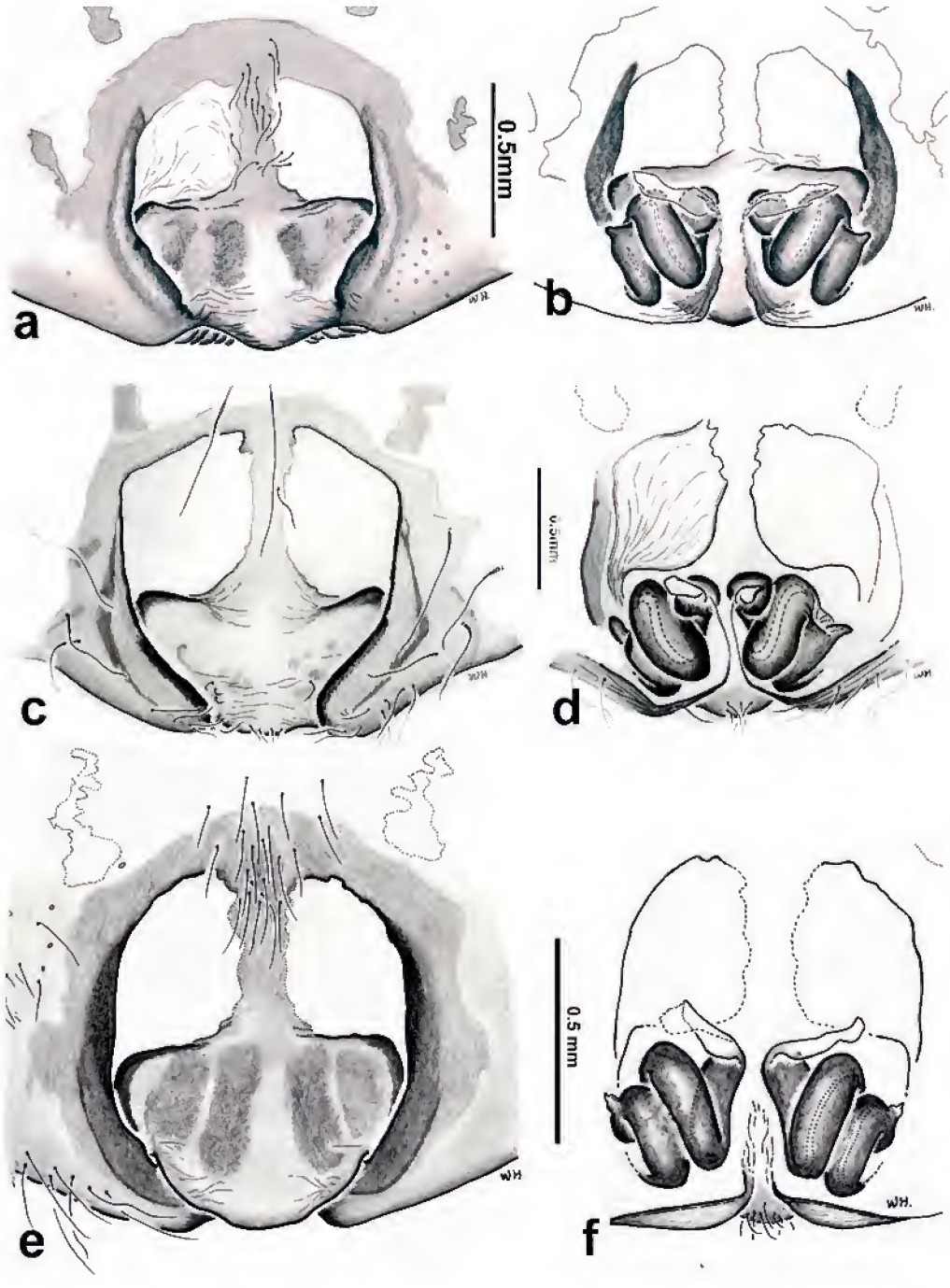


FIG. 14. *Dolomedes instabilis* L. Koch, 1876, female, epigyne. **a, b,** QM S37433. **a,** external, **b,** internal; **c, d,** *Dolomedes habilis* Hogg, 1906, syntype, Gilbert River, SAM NN319. **c,** external; **d,** internal. **e, f,** Lake George, ANIC. e, external; f, internal.

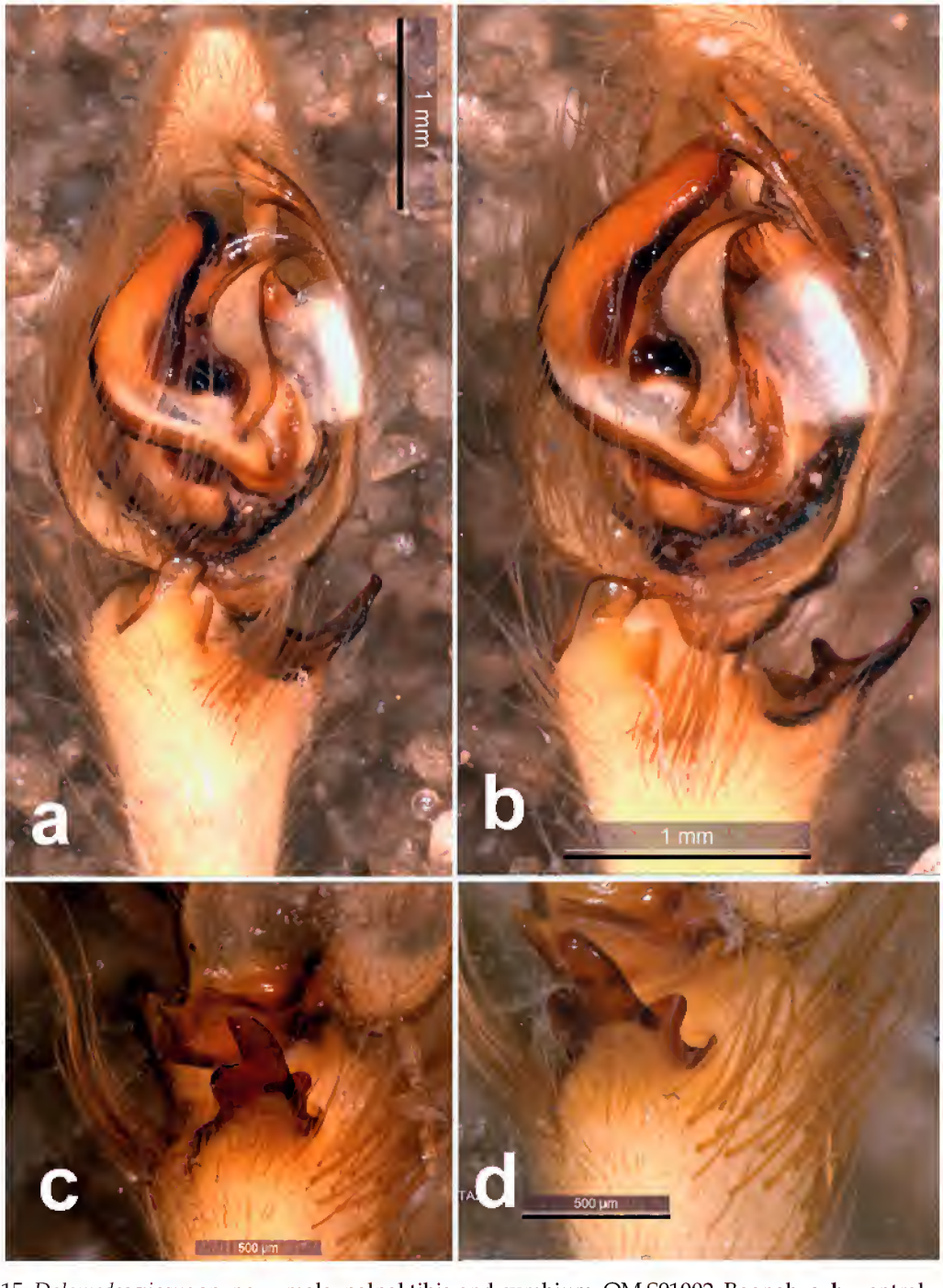


FIG. 15. *Dolomedes vicque* sp. nov., male, palpal tibia and cymbium, QM S91002, Boonah. **a, b,** ventral views; **c, d,** retrolateral tibial apophysis, c, RTAmax, d, retrolateral views.

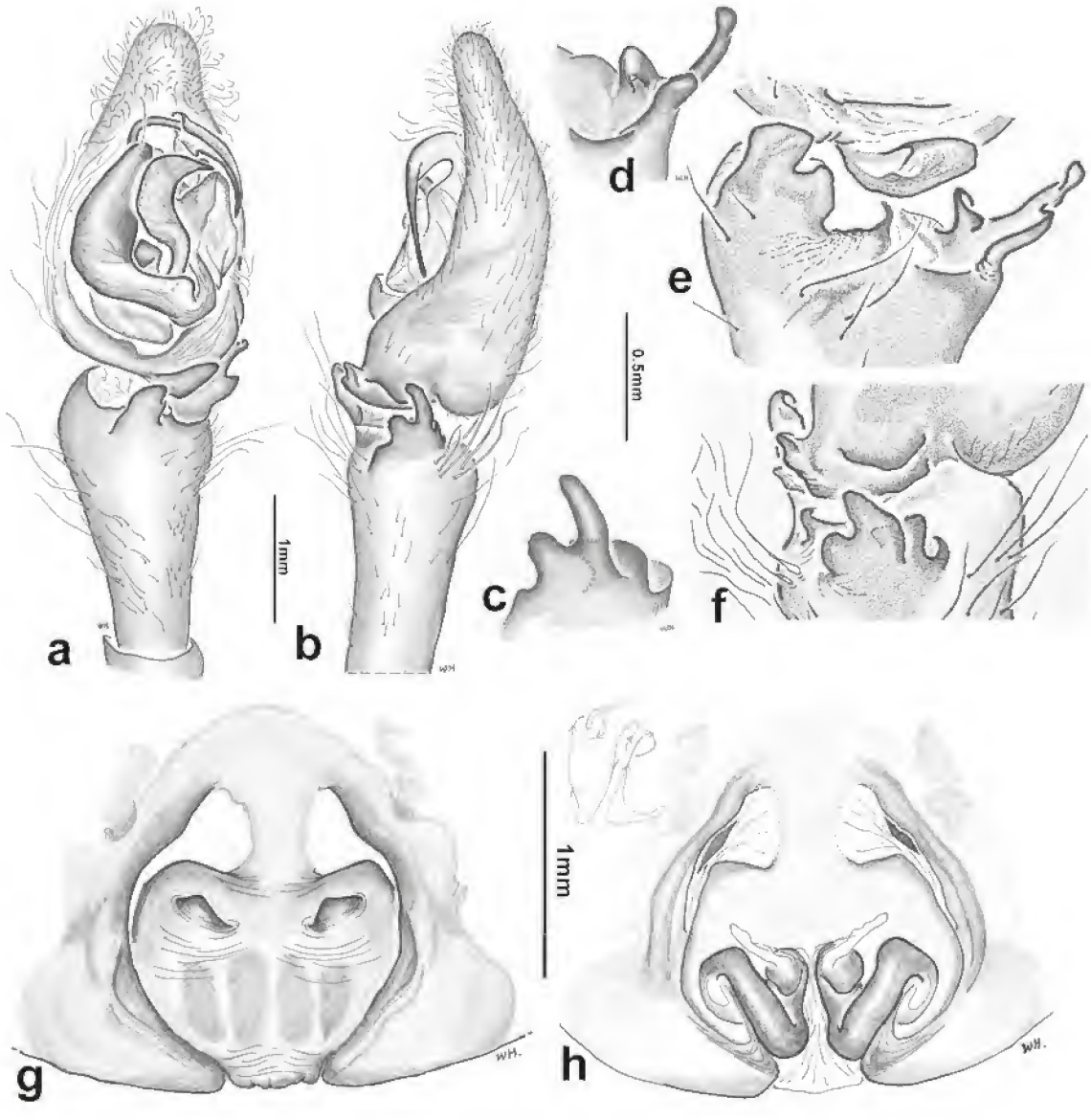


FIG. 16. *Dolomedes vicque* sp. nov., **a–f,** male, palpal tibia and cymbium. **a–d,** QM S28794, Otway Ranges, Victoria. **a, d,** ventral views; **b, c,** retrolateral views. **e, f,** Minnamurra Falls, New South Wales, AM KS124037. **e,** ventral view; **f,** retrolateral view. **g, h,** epigyne, Avon River, Victoria, QM S63911: **g,** external; **h,** internal views.

FIG. 17. *Dolomedes* species, habitus, dorsal view. **a, b,** *Dolomedes briangreenei* sp. nov., habitus: **a,** male QM S84867; **b,** female, Mt Coot-tha. Images, QM; **c,** *Dolomedes vicque* sp. nov., male, Avon R, Victoria, image, V. Framenau.

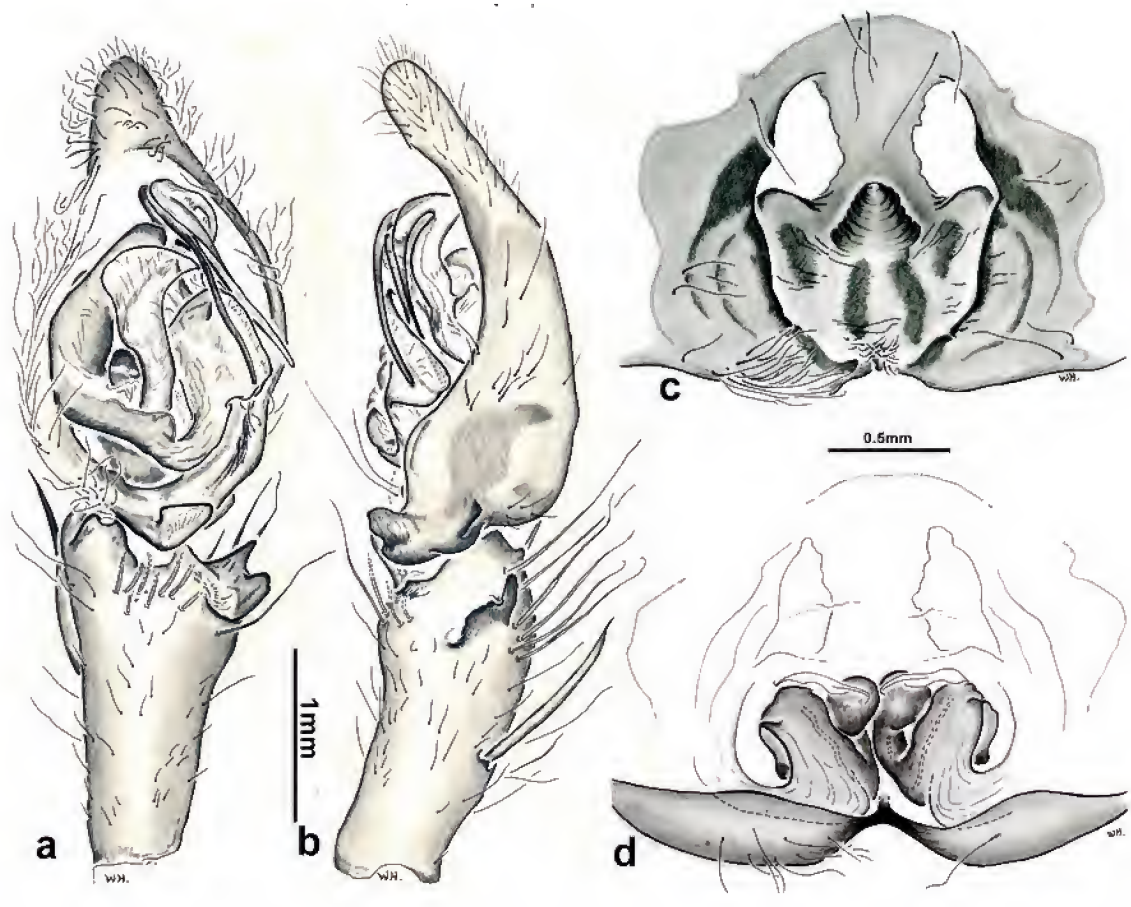


FIG. 18. *Dolomedes briangreenei* sp. nov. **a, b,** holotype male palpal tibia and cymbium, Kroombit Tops, QM S63910. **a,** ventral view; **b,** retrolateral view. **c, d,** female epigyne, same data, QM S63910: **c,** external; **d,** internal views.

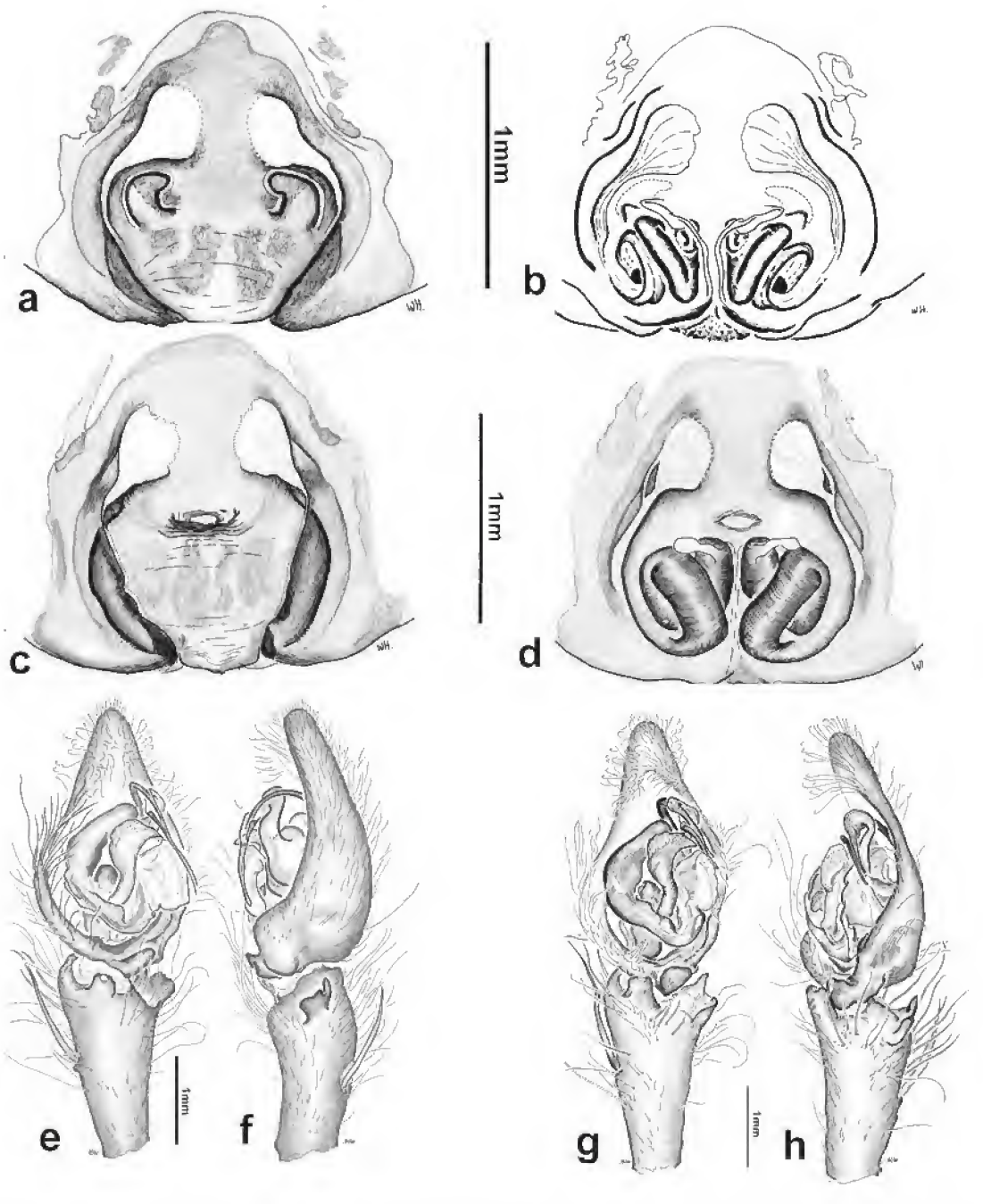


FIG. 19. *Dolomedes briangreenei* sp. nov. a–d, epigynes. **a, b,** Conondale Range, QM S67744. **a,** external; **b,** internal. **c, d,** Mt Warning, New South Wales, QM S67743. **c,** external; **d,** internal. **e–h,** male, palpal tibia and cymbium: QM S67787, Dandabah; **e,** ventral view; **f,** retrolateral view. QM S84867, Redlands: **g,** ventral view; **h,** retrolateral view.

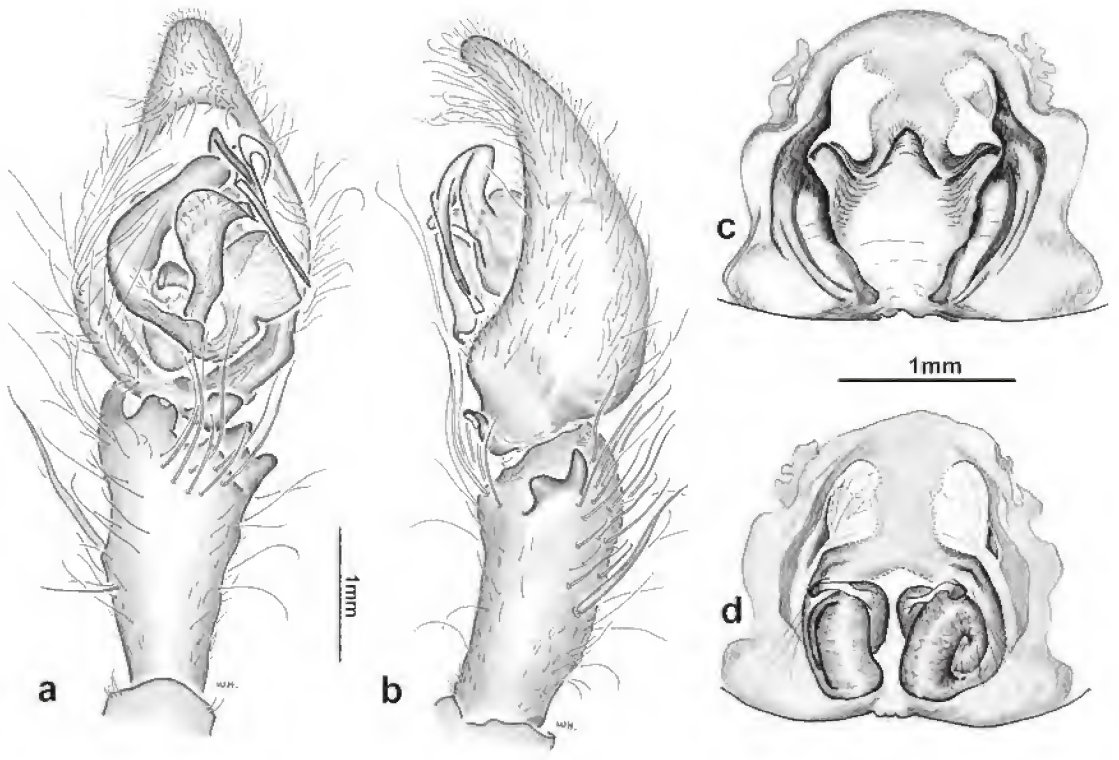


FIG. 20. *Dolomedes briangreenei* sp. nov. **a, b,** male, palpal tibia and cymbium. QM S67774, Majors Mt, north-east Queensland: **a,** ventral view; **b,** retrolateral view. Female epigyne, QM S40725, Bakers Blue Mt, north-east Queensland: **c,** external; **d,** internal view.

FIG. 21. *Dolomedes venmani* sp. nov., holotype, male QM S67741. **a,** habitus, dorsal view, arrows show paired spines distally on palpal femora; **b,** palpal patella, tibia and cymbium showing curved tibia and normal patella, ventral view.

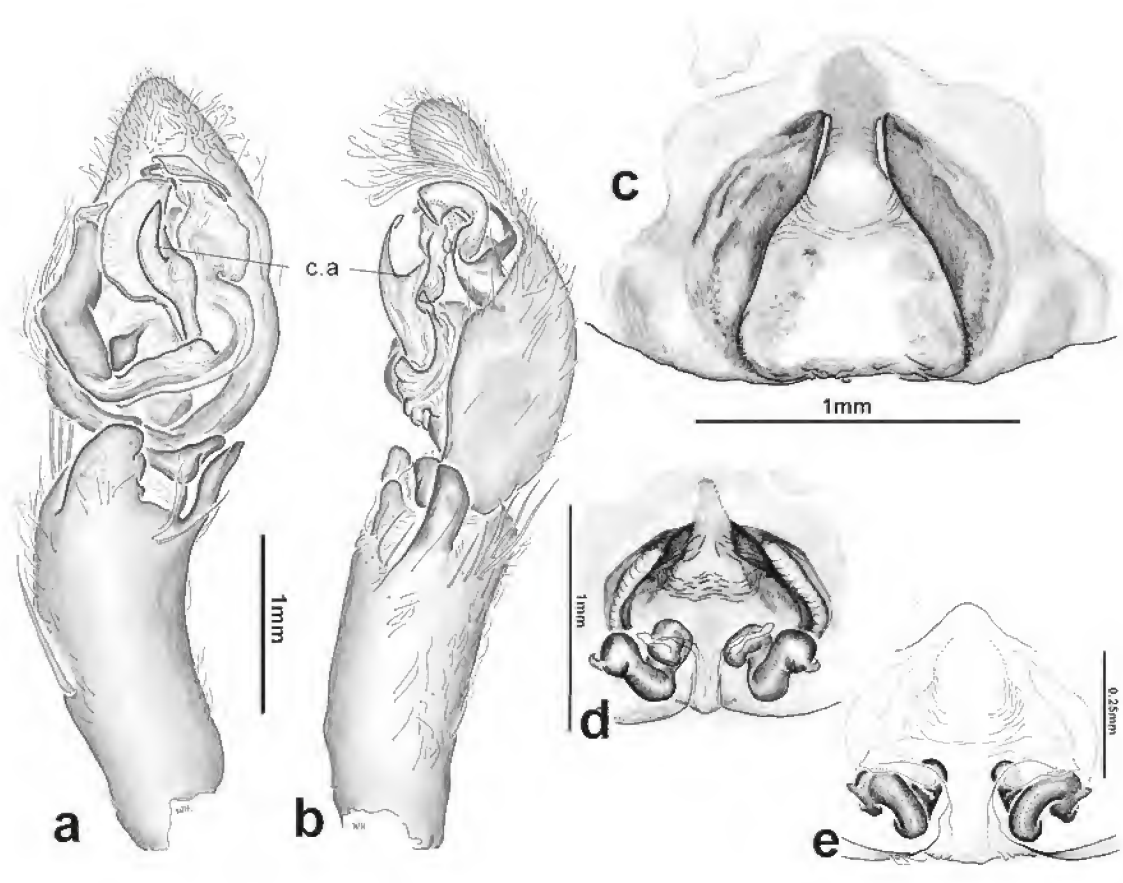


FIG. 22. *Dolomedes venmani* sp. nov. **a, b,** male, QM 91207, palpal tibia and cymbium, **a,** ventral view showing chelate apophysis (c.a); **b,** retrolateral view; **c, d,** female QM S67769, epigyne, **c,** external view; **d,** internal view; **e,** epigyne QM S107091, internal view.

FIG. 23. *Dolomedes flaminius* L. Koch, 1867, holotype male ZMH, habitus. **a,** dorsal view; **b,** ventral view. Images, B. Baehr.

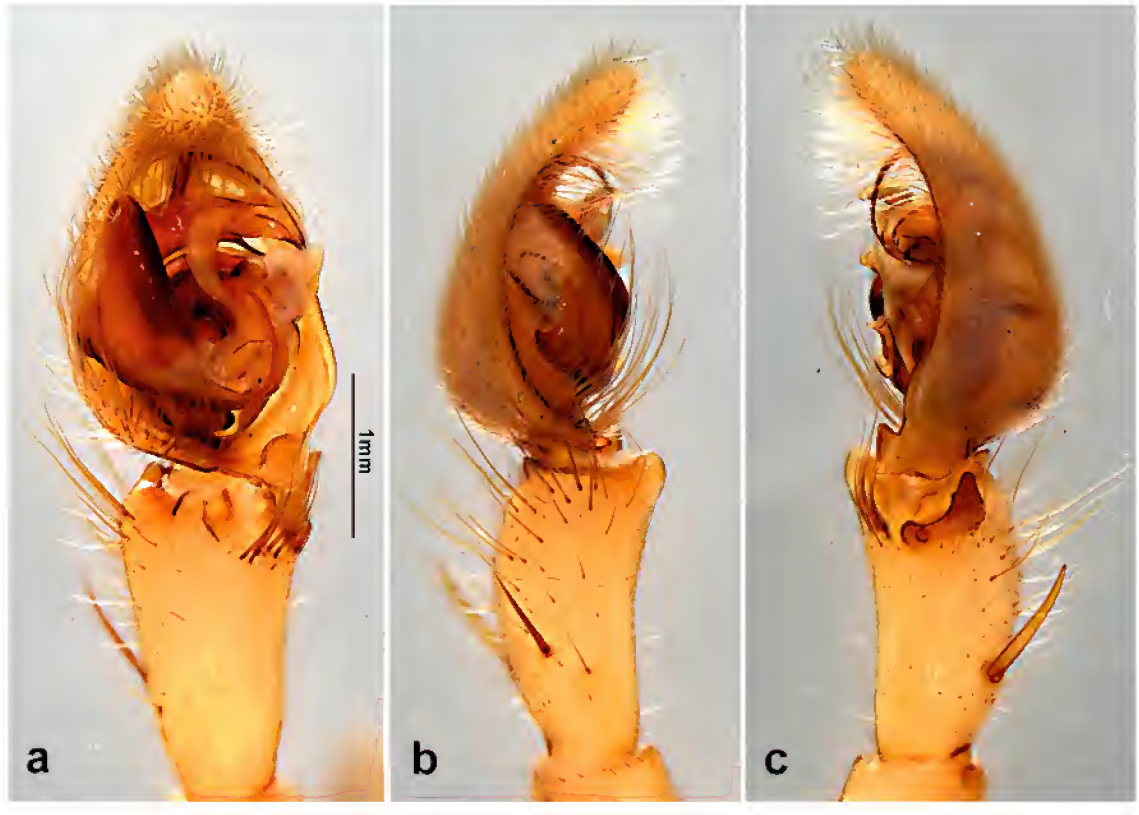


FIG. 24. *Dolomedes flaminius* L. Koch, 1867, holotype male ZMH, palp: **a,** ventral view ; **b,** prolateral view; **c,** retrolateral view. Images, B. Baehr.

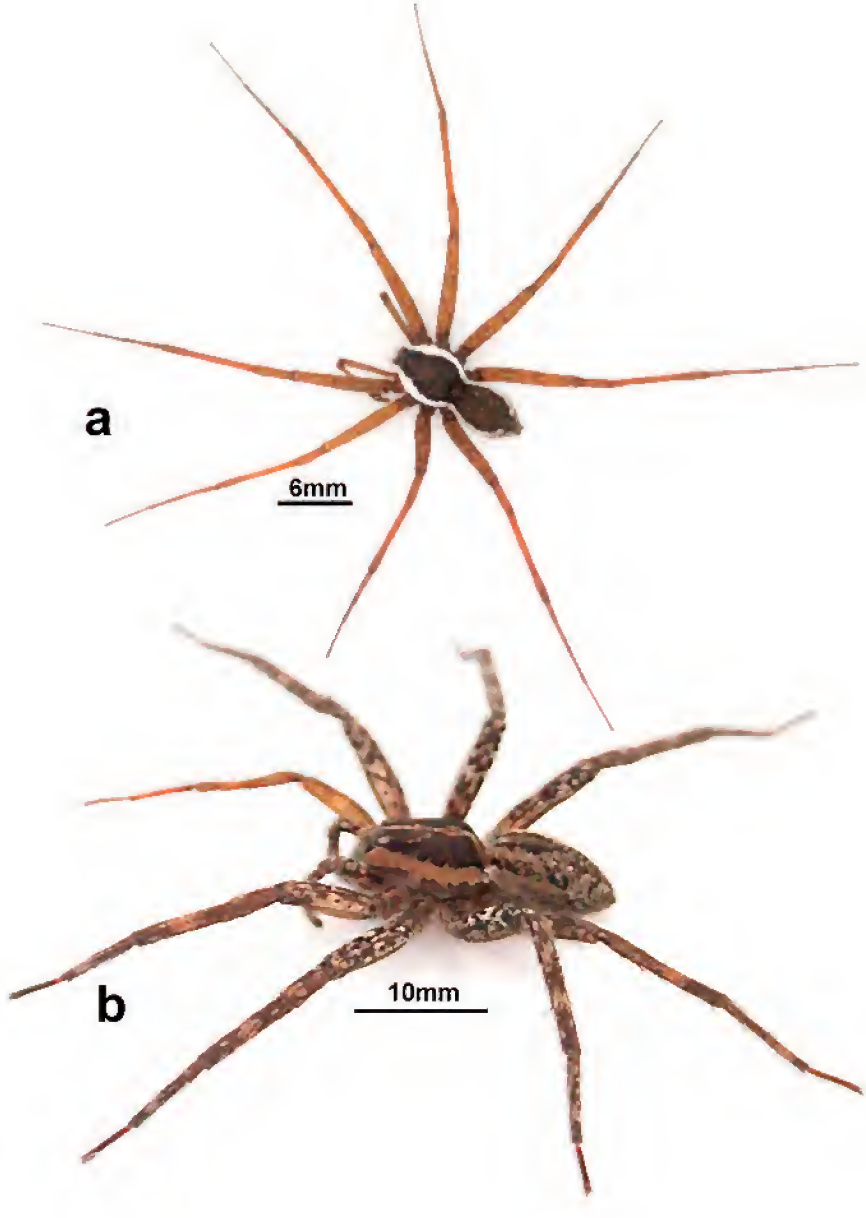


FIG. 25. *Dolomedes wollemi* sp. nov., habitus, dorsal view. **a,** male; **b,** female. Images, J. Wolff.

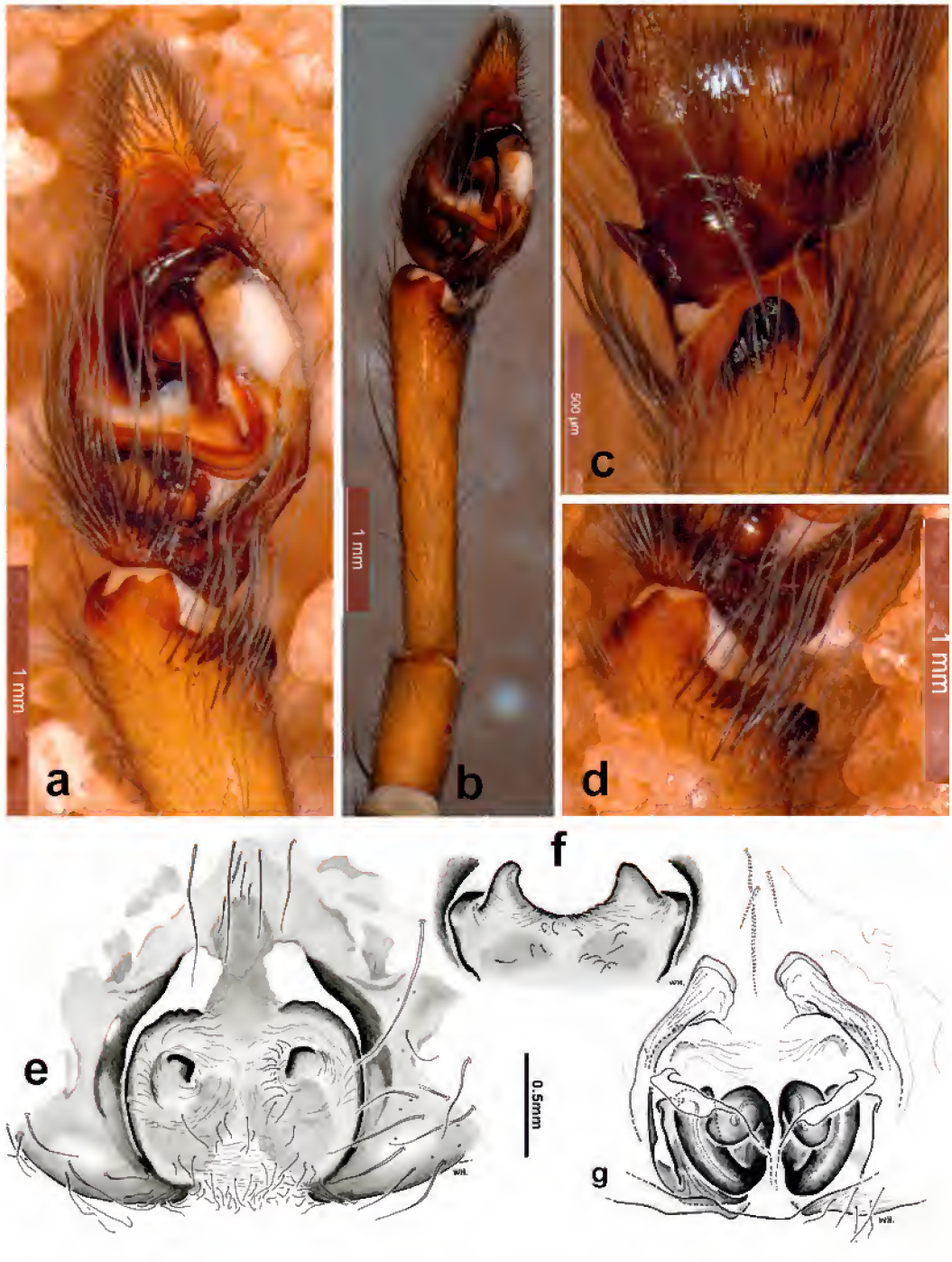


FIG. 26. *Dolomedes wollemi* sp. nov., holotype male AM KS126569, palpal tibia and cymbium. **a, d,** ventral view; **b,** also showing patella, ventral view; **c,** retrolateral view. **e–g,** female epigyne AM KS126570: **e,** external; **f,** posterior axial view of external; **g,** internal view.

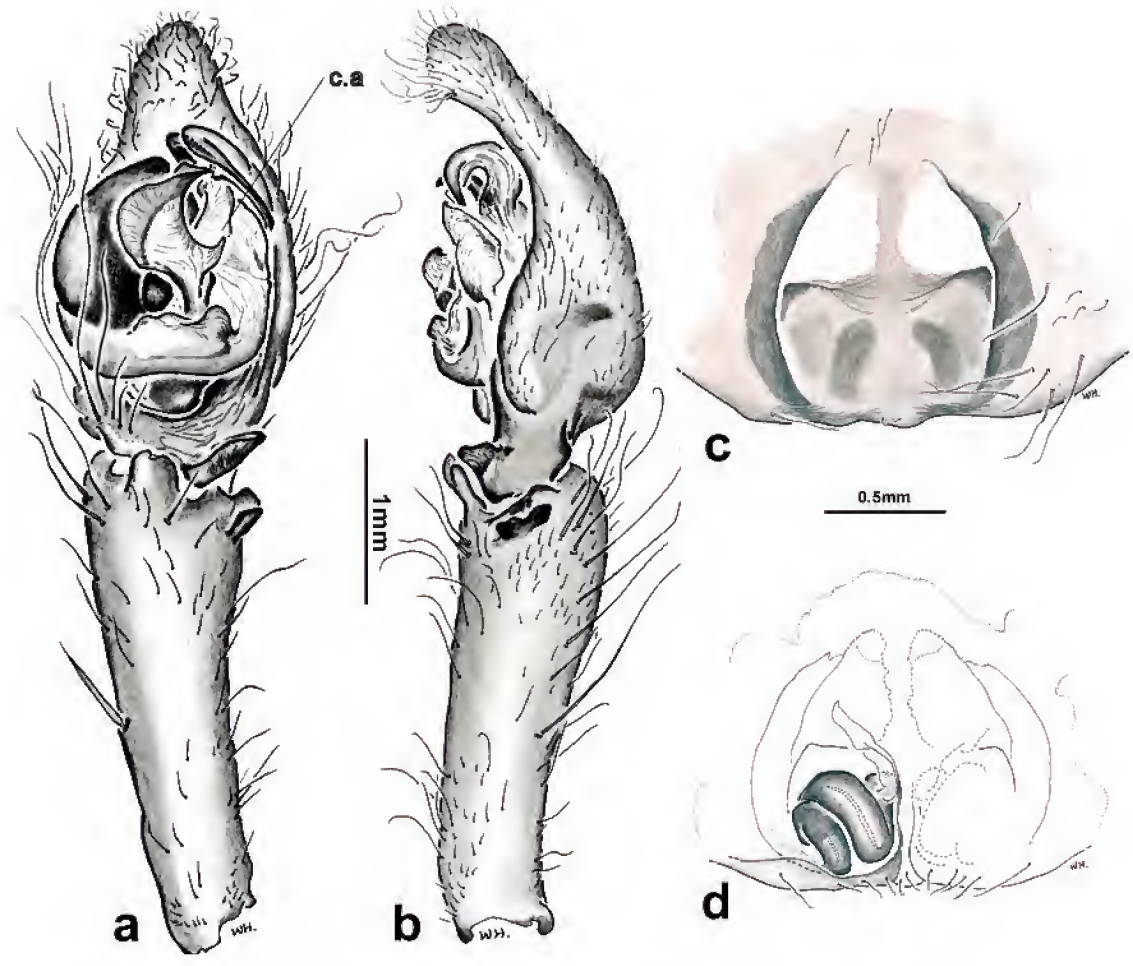


FIG. 27. *Dolomedes mankorlod* sp. nov. a, b, holotype male, MAGNT A004617. **a, b,** palpal tibia and cymbium: **a,** ventral view showing chelate apophysis (c. a); **b,** retrolateral view; **c, d,** female epigyne, MAGNT: **c,** external view; **d,** internal view.

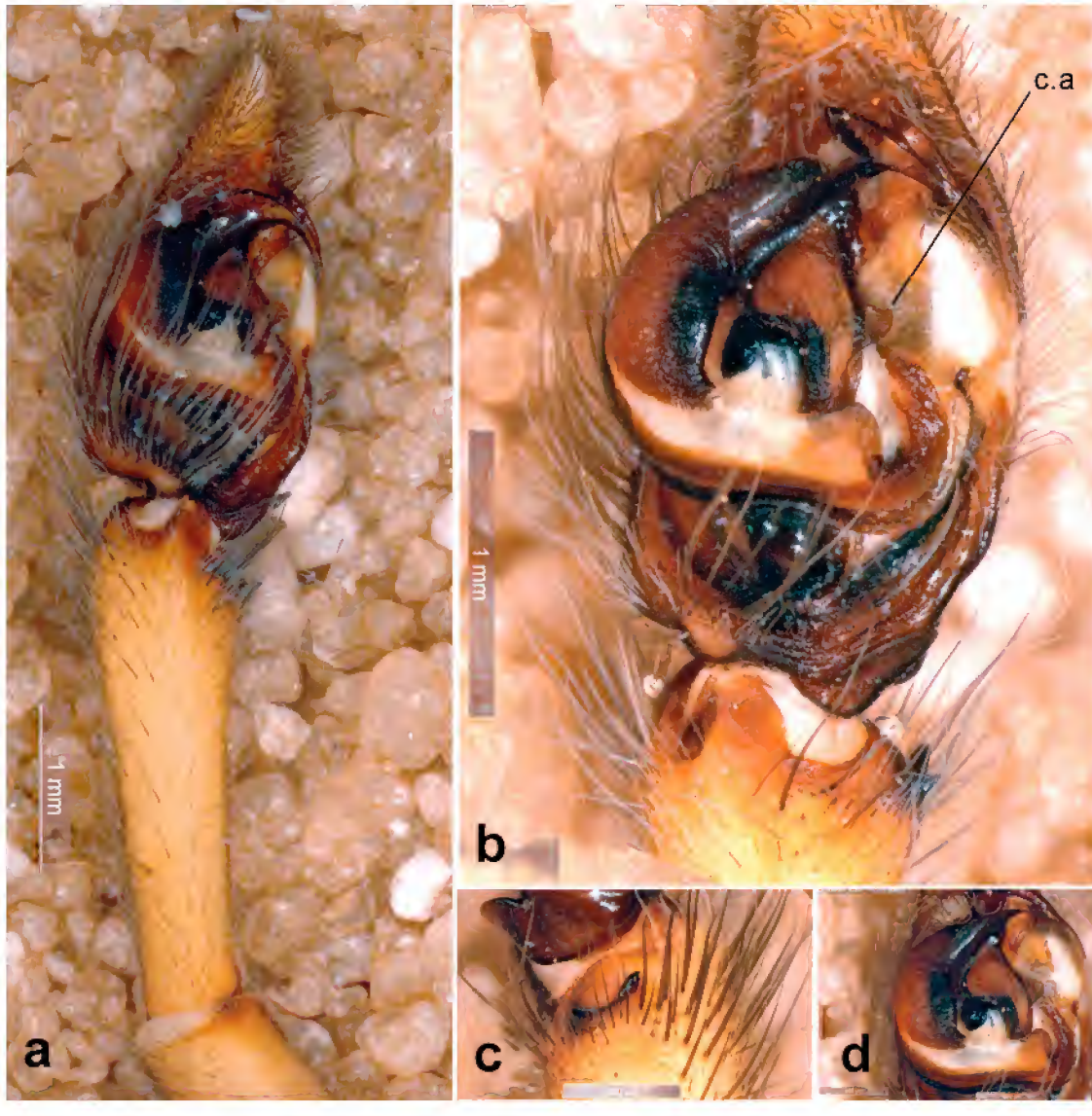


FIG. 28. *Dolomedes karijini* sp. nov. **a–d,** holotype male, WAM T135513, palpal tibia and cymbium. **a, b, d,** ventral view; **c,** retrolateral view.

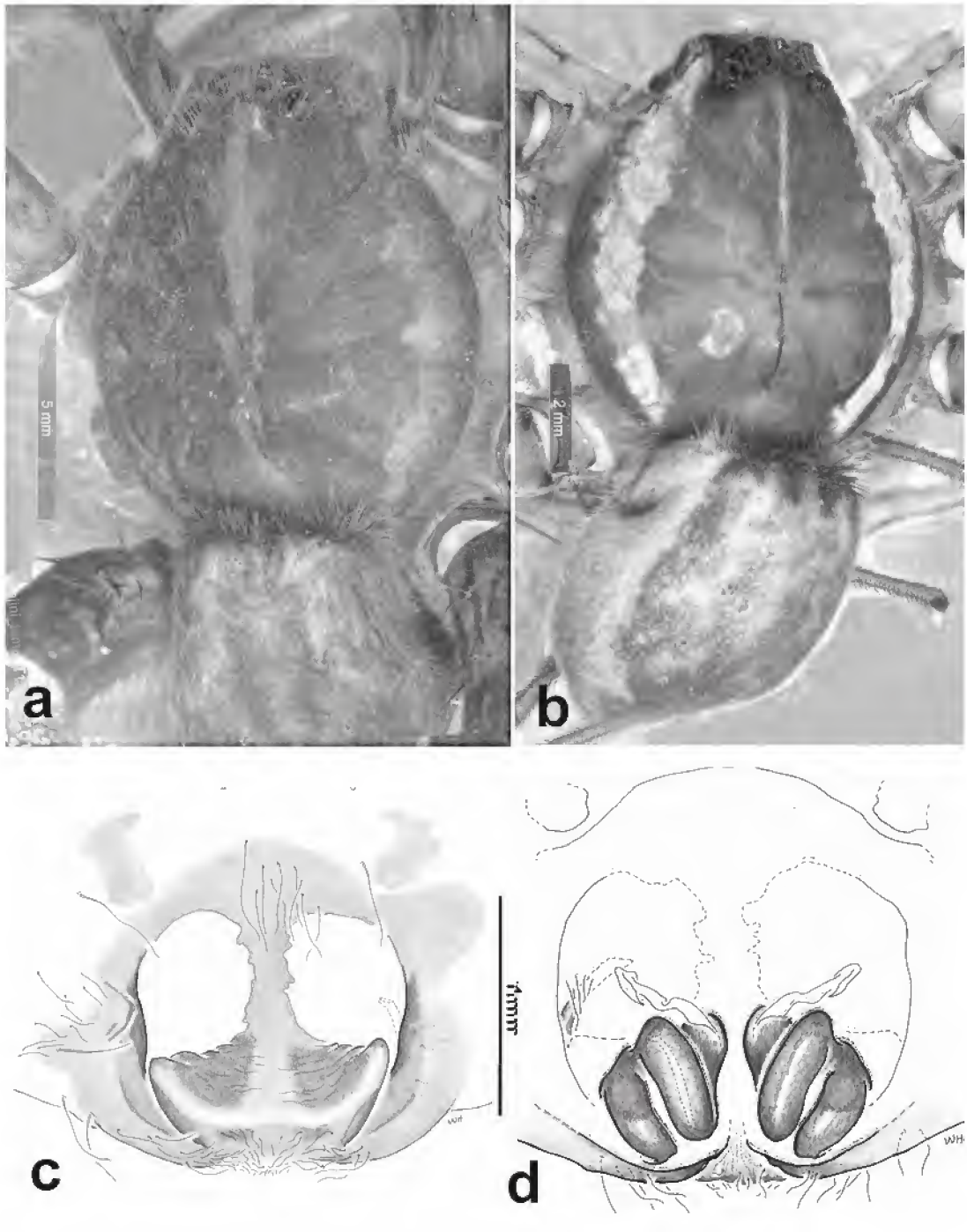


FIG. 29. *Dolomedes karijini* sp. nov. **a, c, d,** female WAM T135645. **a,** habitus, dorsal view; **c, d,** epigyne, external (c), internal (d); **b,** holotype male, WAM T135130, habitus, dorsal view.

FIG. 30. *Dolomedes alexandri* sp. nov., holotype male (ANIC 42:001795). Palpal tibia and cymbium, ventral (a), retrolateral (b) and RTAmax (c) view.

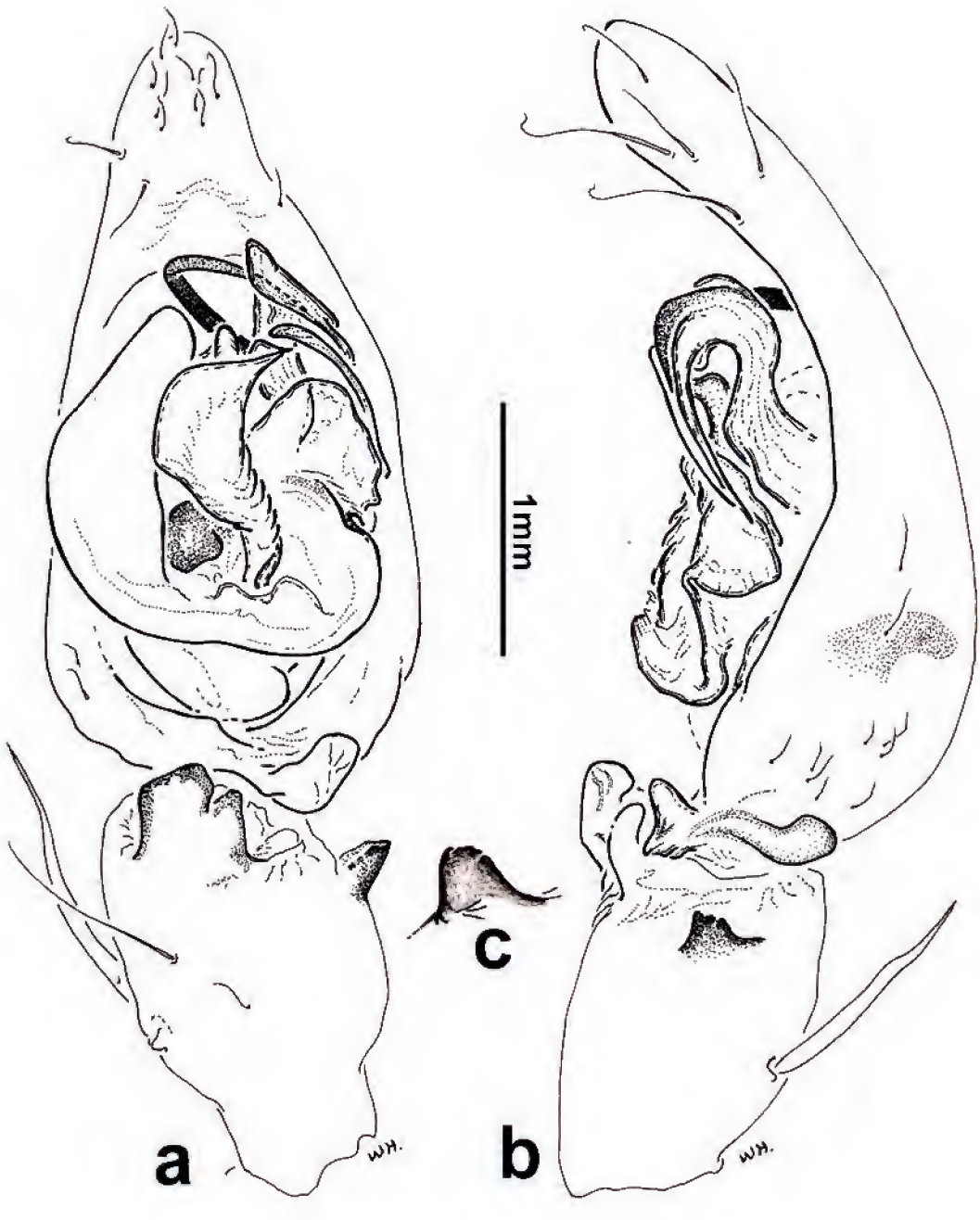


FIG. 31. *Dolomedes alexandri* sp. nov., holotype male (ANIC 42:001795), palpal tibia and cymbium. Ventral (a), retrolateral (b) and RTAmax (c) view, scale line for c=0.7 mm.

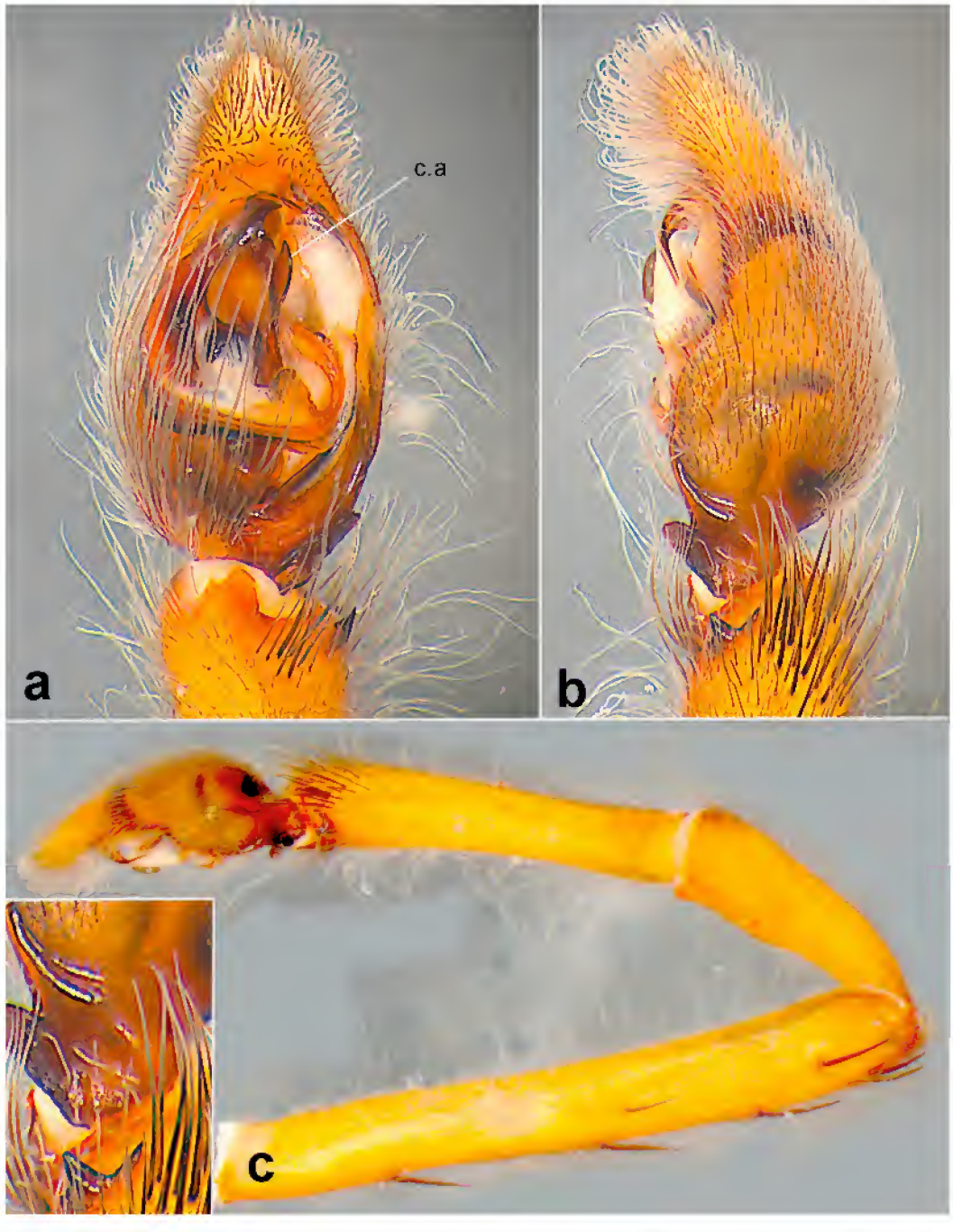


FIG. 32. *Dolomedes lizturnerae* sp. nov., holotype male TMAG J4124. **a–c,** Tibia, cymbium and bulb. a, Ventral view showing chelate apophysis (c.a). b, Retrolateral view. Inset. RTA and cymbium base, RTAmax view. **c,** Palpal femur to cymbium, retrolateral view.

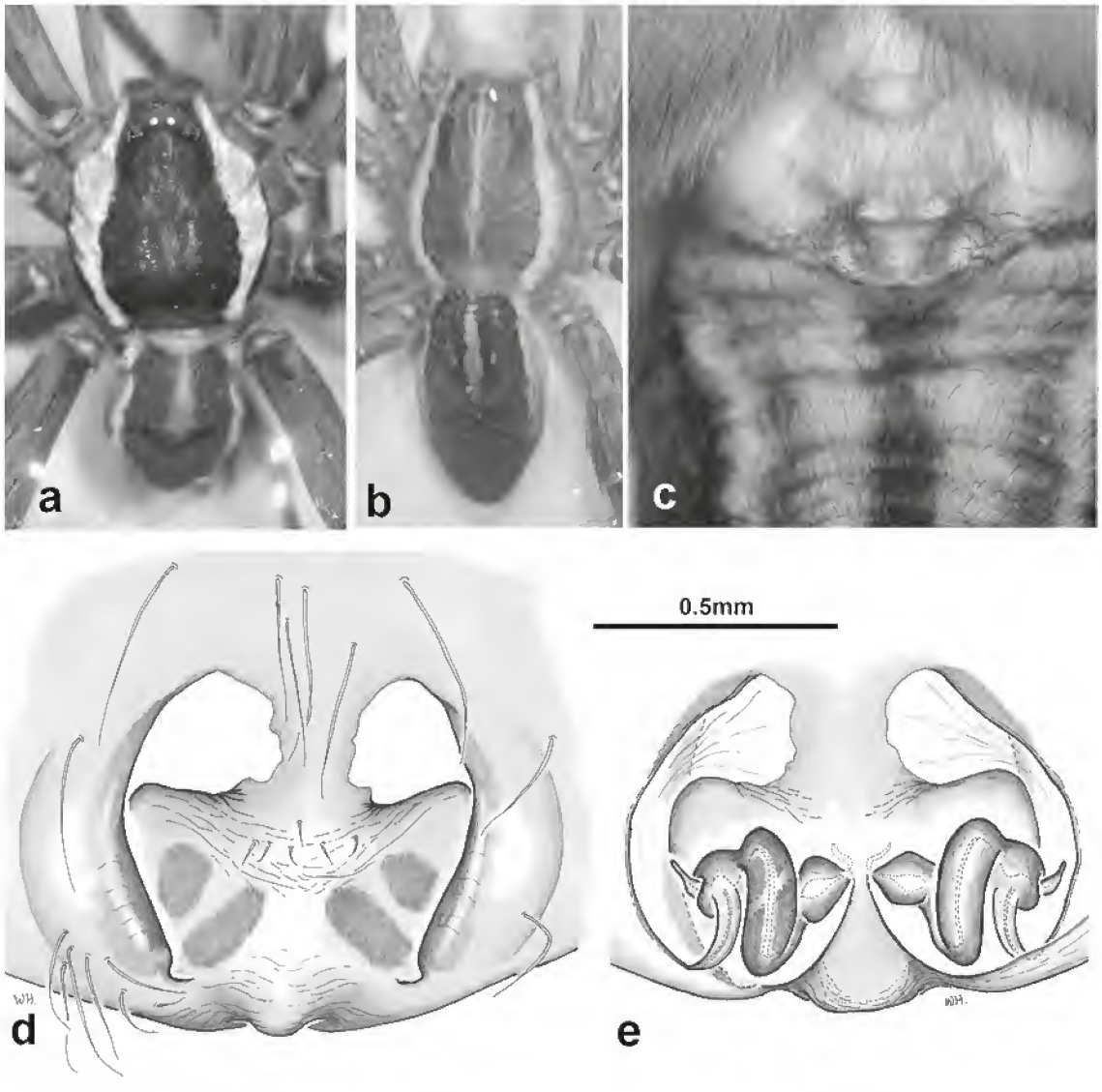


FIG. 33. *Dolomedes lizturnerae* sp. nov. **a,** holotype male TMAG J4124, habitus, dorsal view. **b–e,** female TMAG J4125, **b,** habitus, dorsal view; **c,** abdomen, ventral view showing pattern; **d–e,** epigyne, external (d) and internal (e) view.

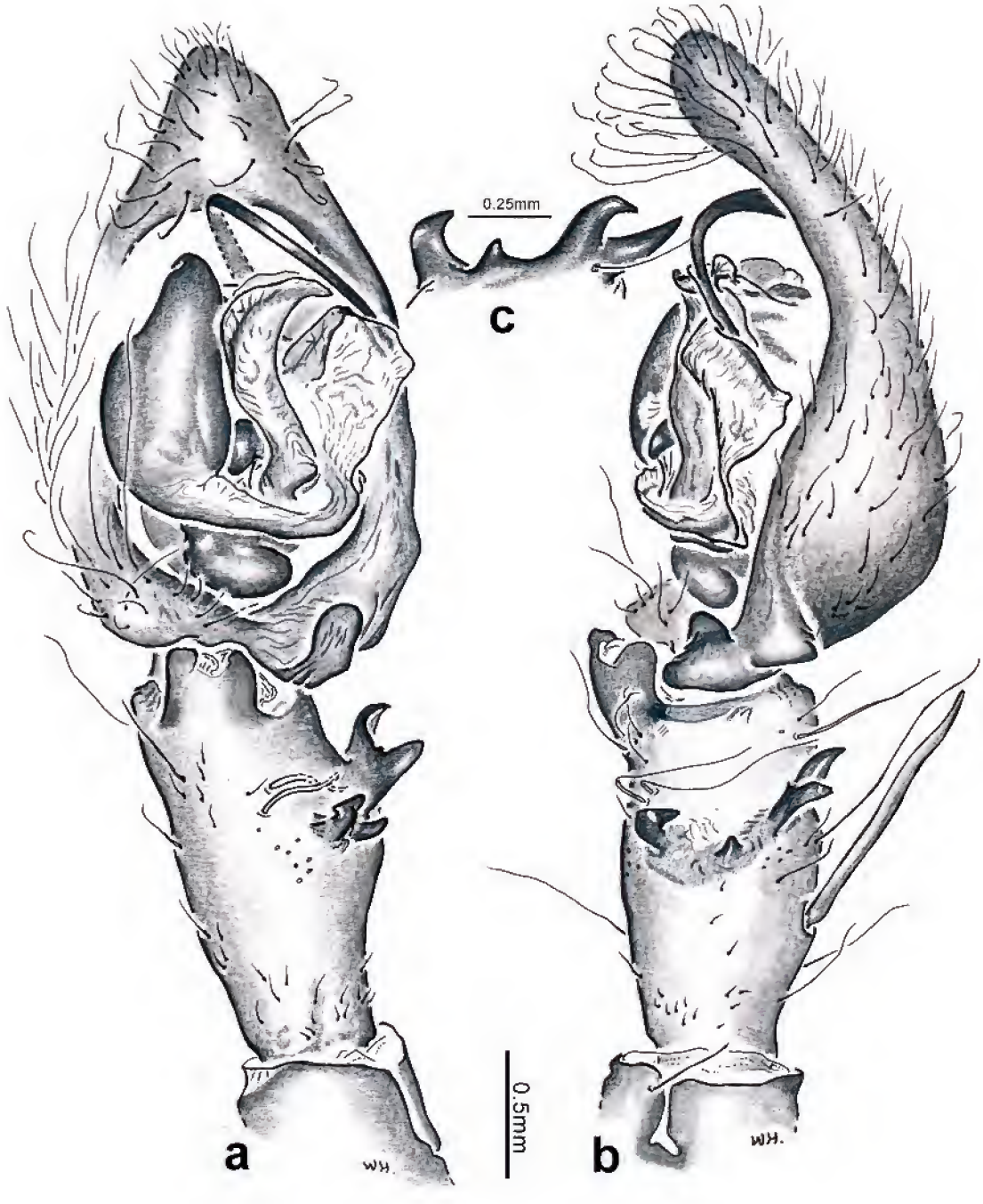


FIG. 34. *Dolomedes pedder* sp. nov., holotype male, AM KS107495, palpal tibia and cymbium. Ventral **a,** retrolateral; **b,** and RTAmax; **c** ,view.

FIG. 35. *Dolomedes titan* Berland, 1924, female QM S13542, habitus.

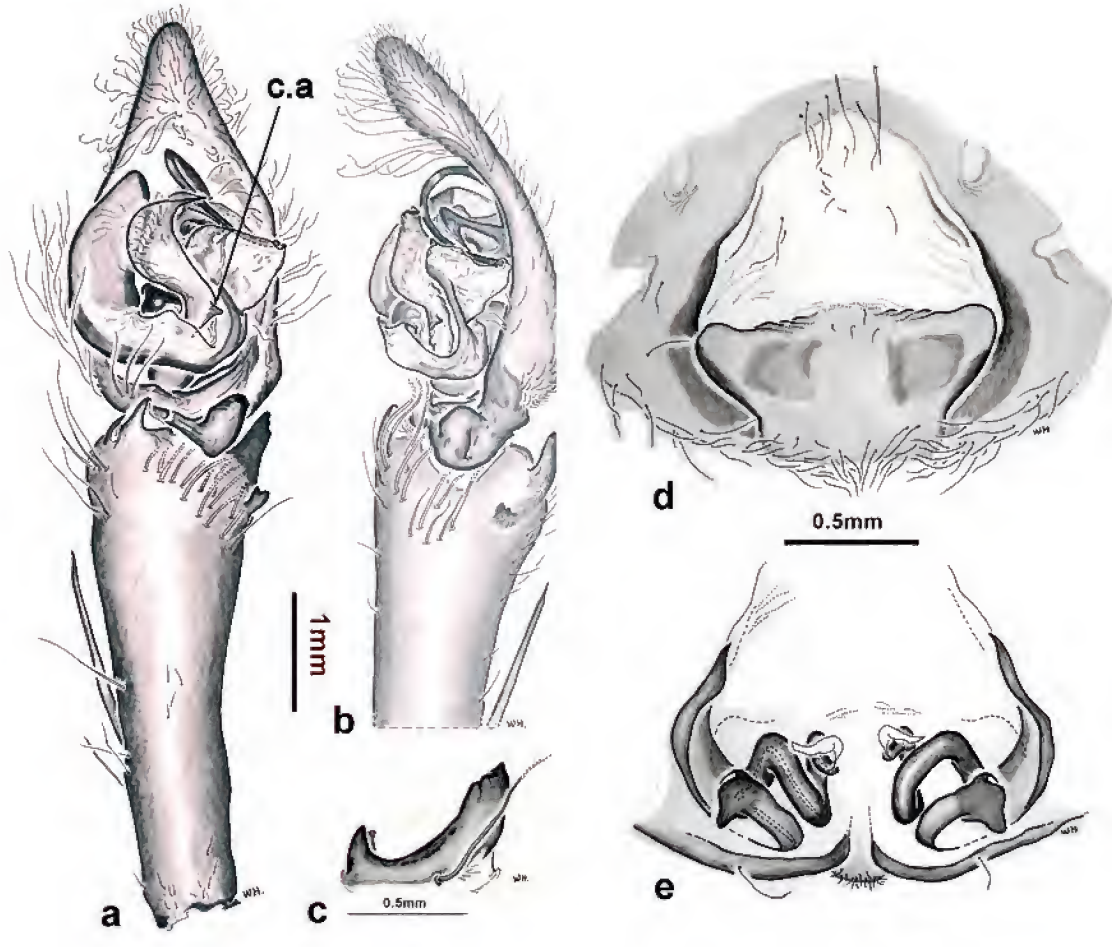


FIG. 36. *Dolomedes titan* Berland, 1924, male (QM S30678) and female (QM S13542). **a, b,** palpal tibia and cymbium, ventral showing chelate apophysis (c.a) (a) and retrolateral (b) view; **c,** retrolateral tibial apophysis, RTA max view; **d, e,** epigyne, external (d) and internal (e) views.

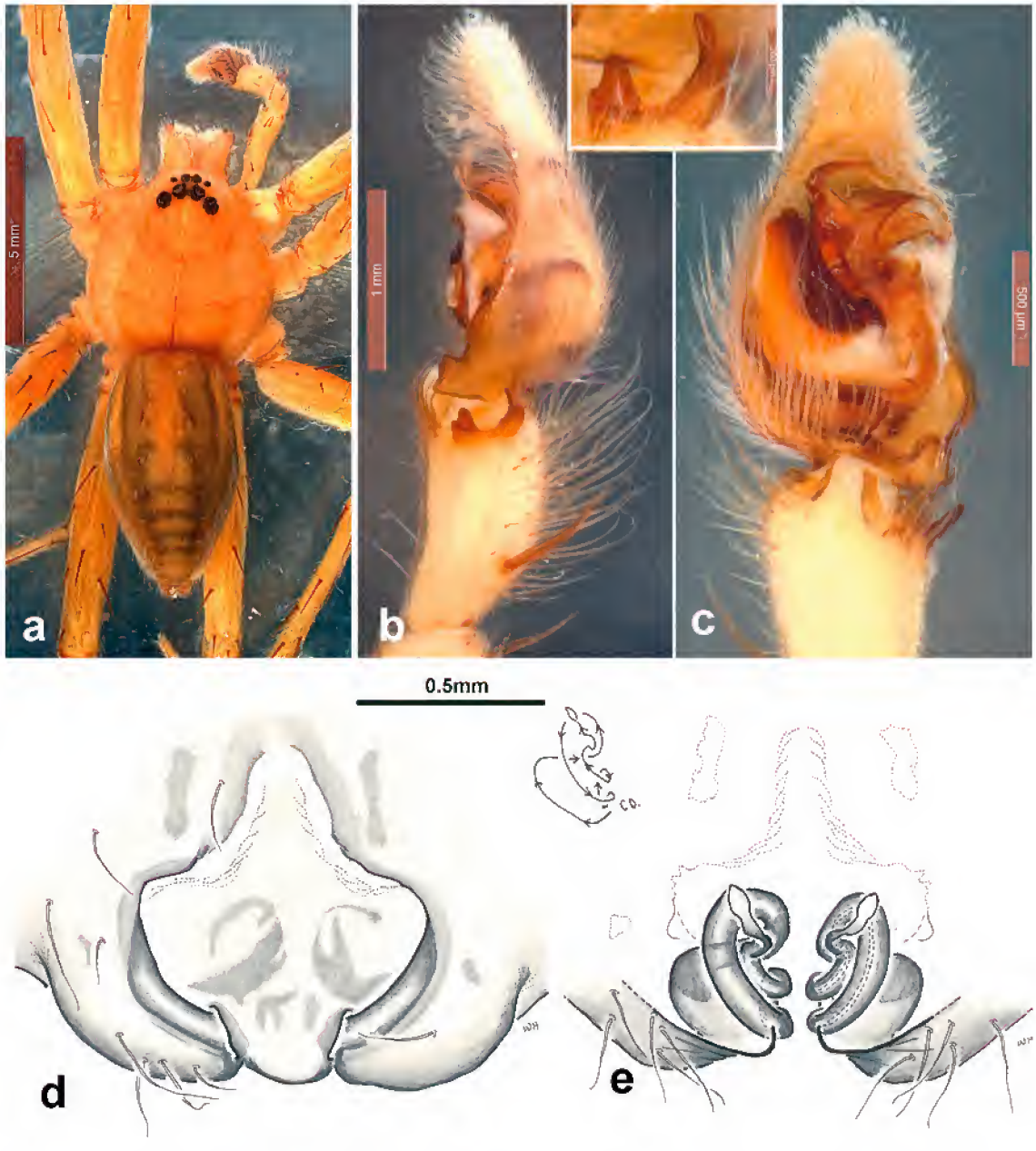


FIG. 37. *Dolomedes neocaledonicus* Berland, 1924. **a–c,** male QM S13826; **a,** habitus, dorsal view; **b, c,** palpal tibia and cymbium: **b,** retrolateral view; inset, RTA, maximal view, ventral (c) view; **d, e,** female MNHP 3.85, epigyne, external (d) and internal (e) views.

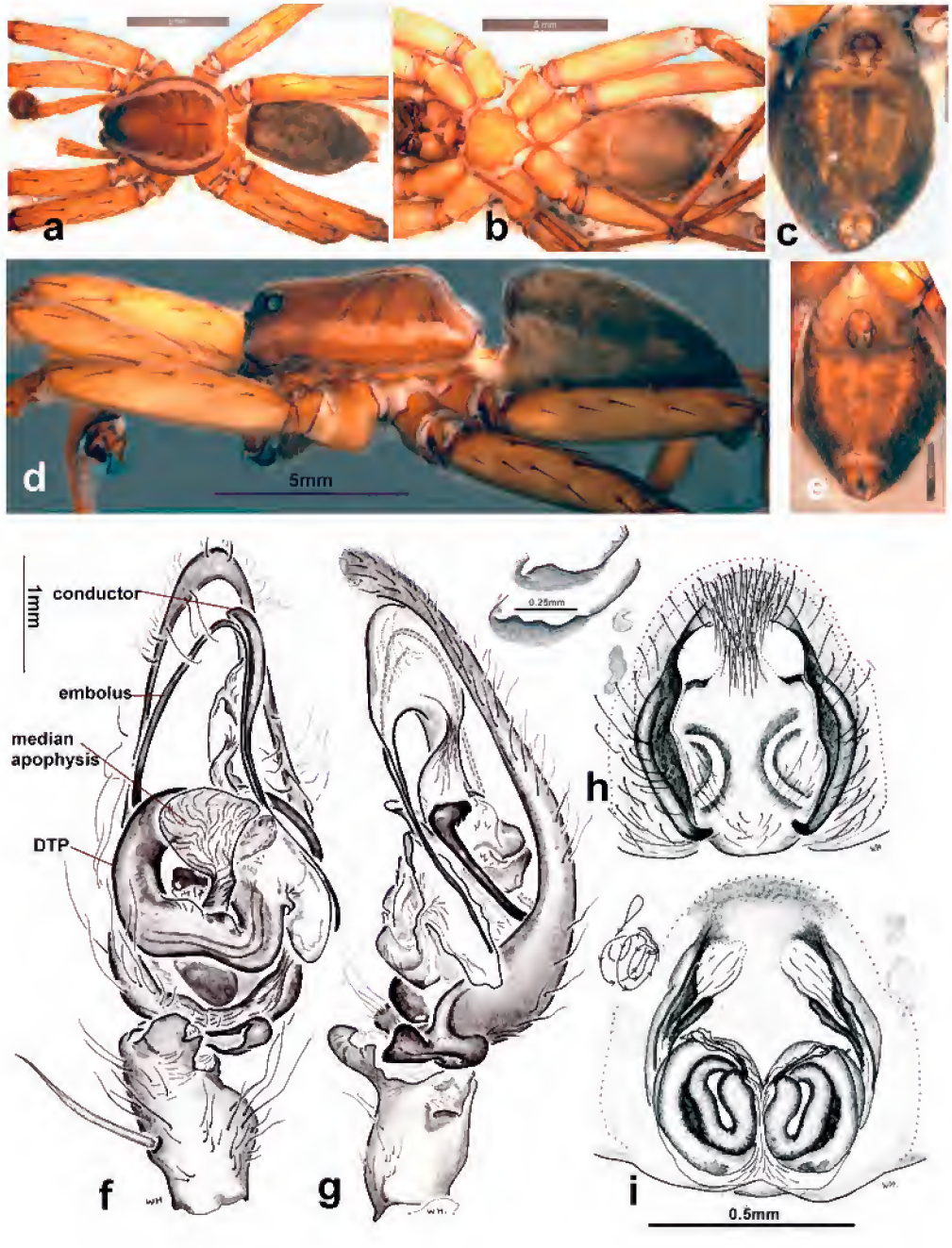


FIG. 38. *Tasmomedes eberhardarum* (Strand, 1913). **a–g,** male; **a, b, d,** QM S48771; a, habitus, dorsal view; **a,** habitus, ventral view; **d,** habitus, lateral view; **c, e,** female habitus, ventral view, QM S70499 (c), QM S75700 (e); **f, g,** male, palpal tibia and cymbium, QM S22403; **f,** ventral view; **g,** retrolateral view; inset showing RTAMax view, QM S67787; epigyne, external **(h)** and internal **(i)** views. Abbreviation: DTP, distal tegular process.

FIG. 39. *Megadolomedes*, habitus. **a–c,** *Me. trux* (Lamb, 1911), habitus, dorsal view: **a, b,** female; **b,** male, ca. twice its size cf. female figured; **c,** face of female; **d,** *Me. johndouglasi* sp. nov. female, habitus, dorsal view.

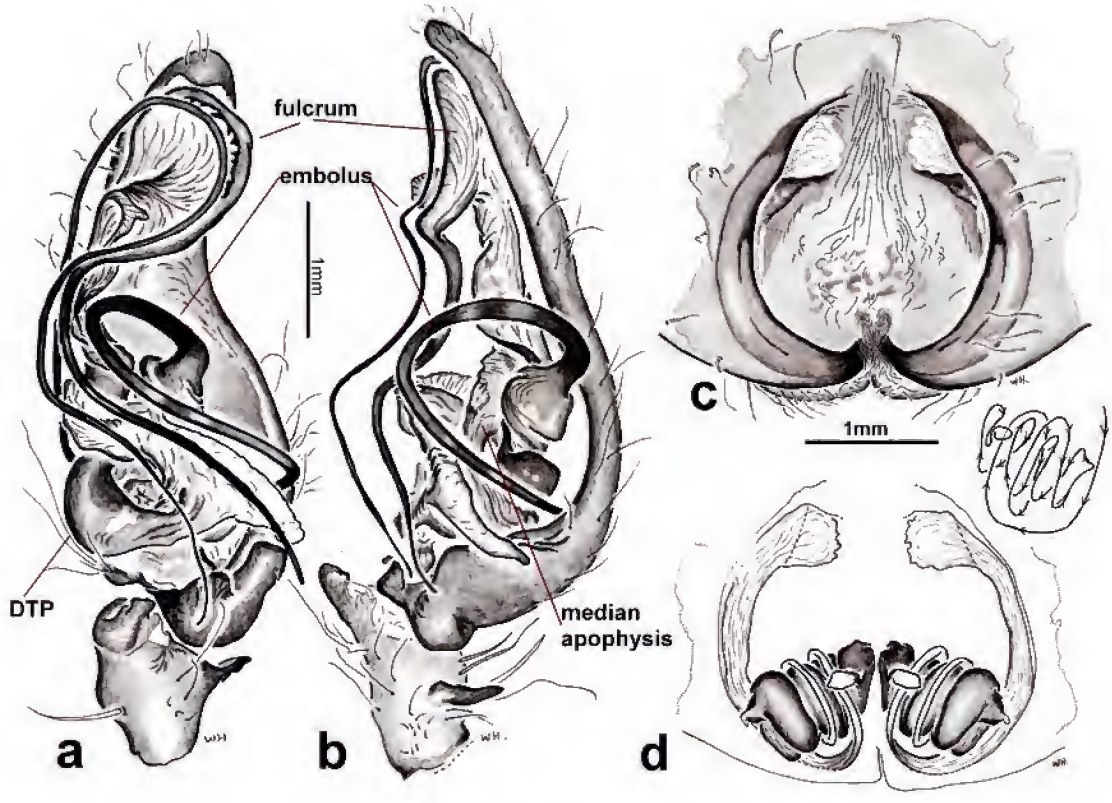


FIG. 40. *Megadolomedes australianus* (L. Koch, 1865), male, AM KS39496. **a, b,** Palpal tibia and cymbium, ventral (a) and retrolateral (b) view; female ANIC 42-002260, Minnamurra Falls, New South Wales, epigyne, external (c) and internal (d), with spermathecal path) views. Abbreviation: DTP, distal tegular process.

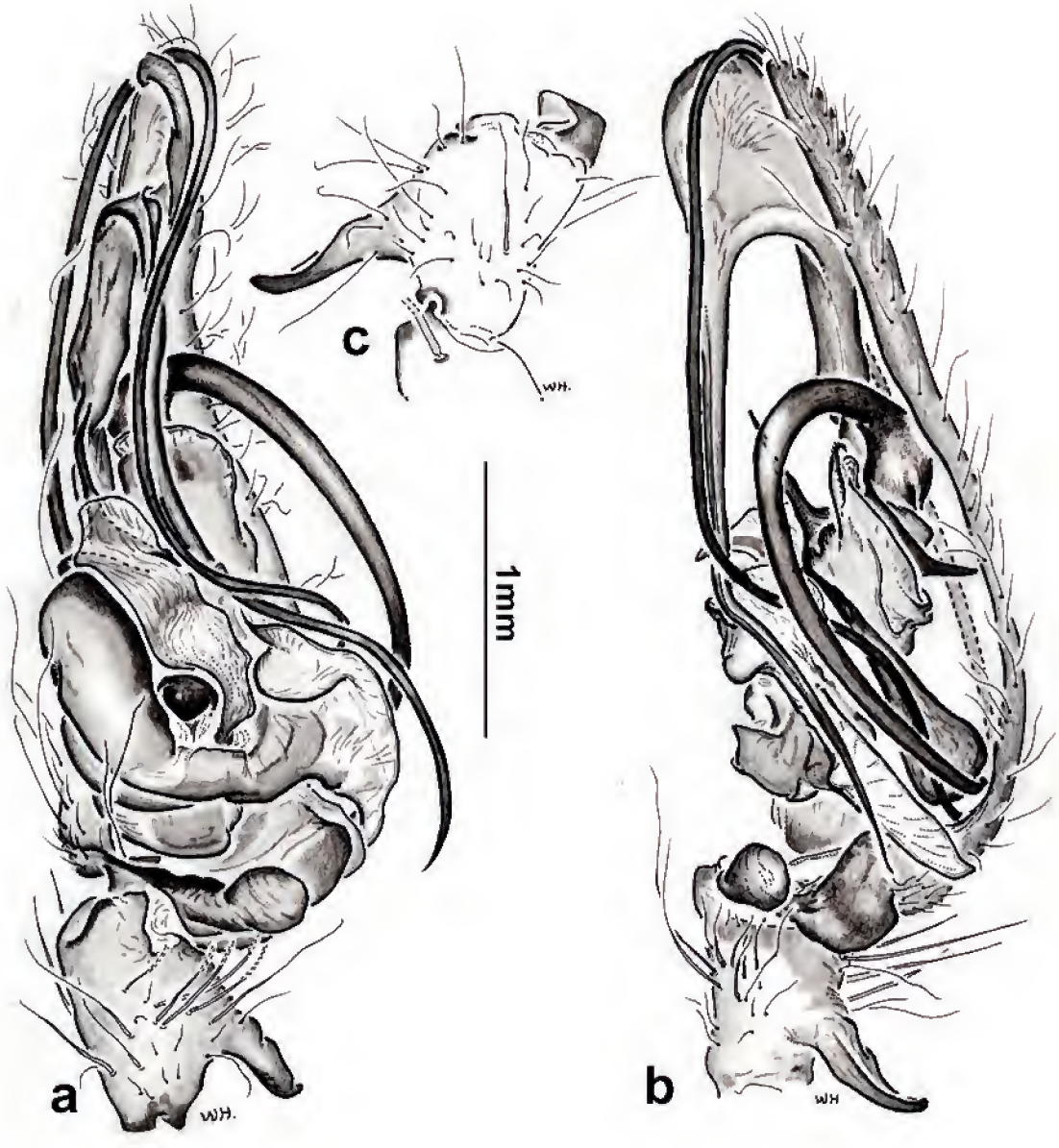


FIG. 41. *Megadolomedes trux* (Lamb, 1911), male QM S79215, palpal tibia and cymbium. **a,** ventral view; **b,** retrolateral view; **c,** dorsal view of RTA.

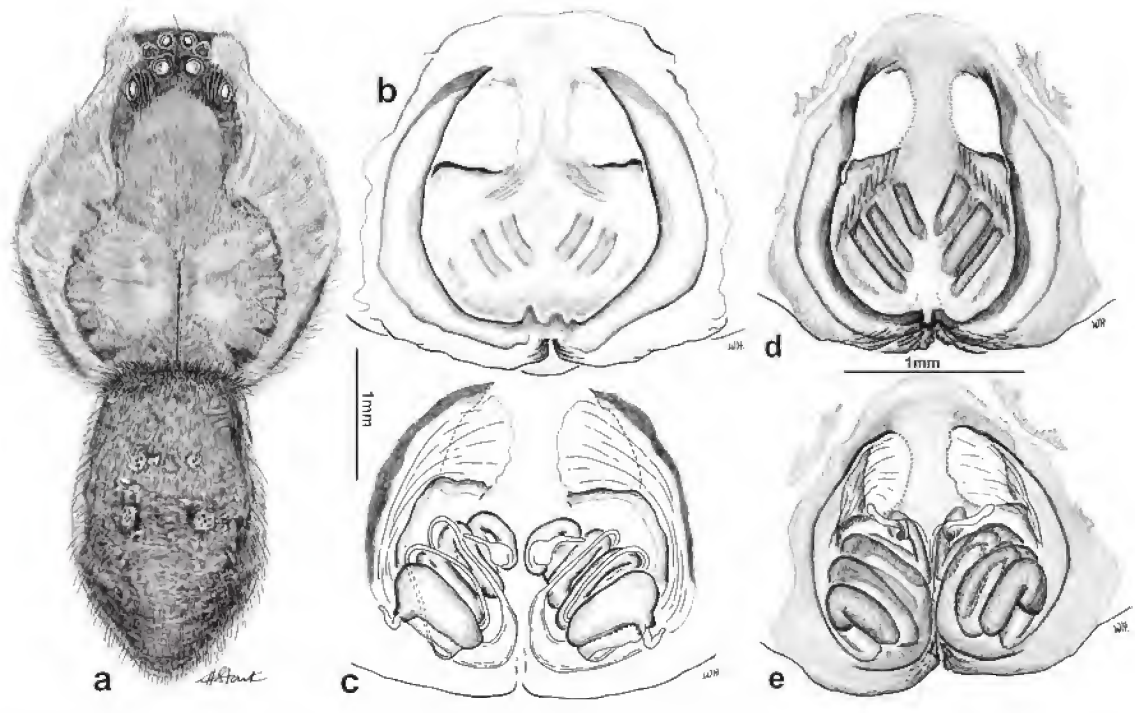


FIG. 42. *Megadolomedes*. **a–c,** *Me. trux* (Lamb, 1911), female, Kroombit Tops. a, habitus, dorsal view; b, c, Mt Tamborine, QM S13478, epigyne, external (b) and internal (b) view; **d, e,** *Me. nord* sp. nov., holotype, QM S67749, female epigyne, external (d) and internal (e) views.

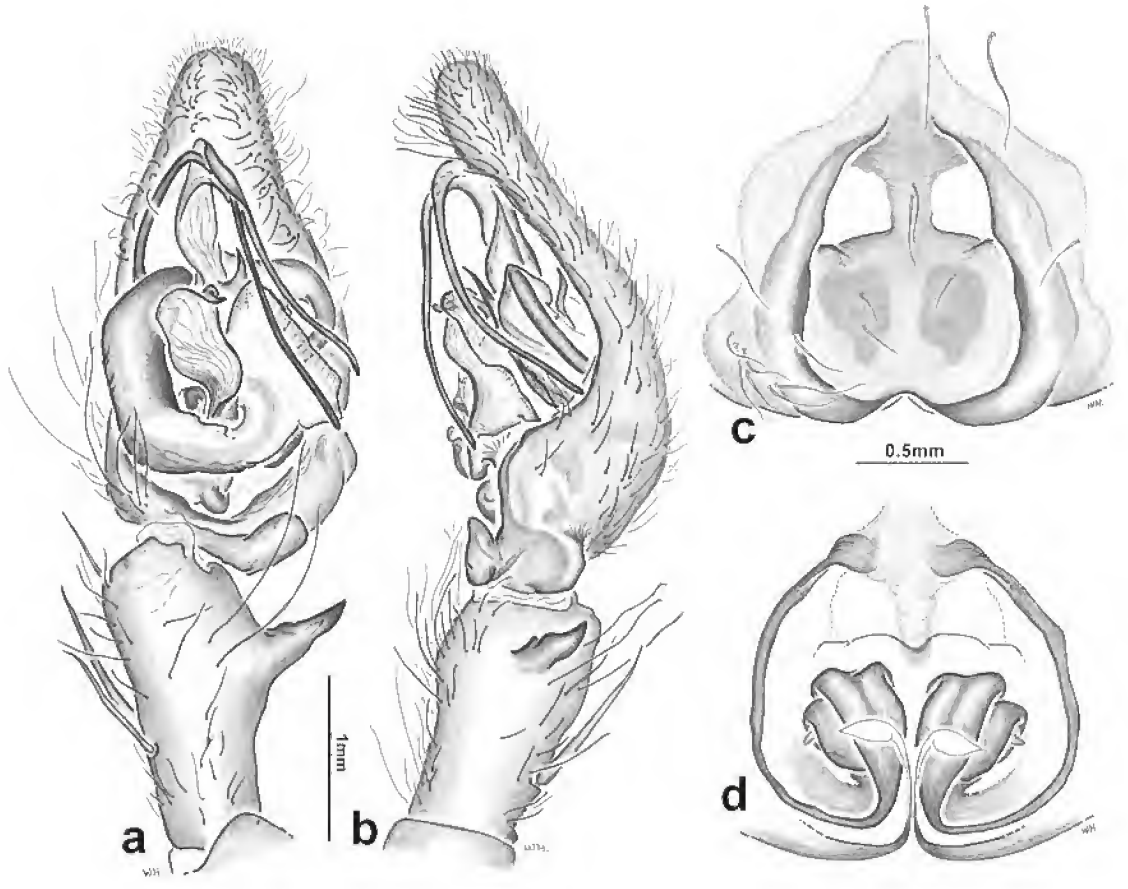


FIG. 43. *Megadolomedes johndouglasi* sp. nov. **a, b,** holotype male QM S28796; palpal tibia and cymbium: **a,** ventral view; **b,** retrolateral view. **c, d,** female paratype, TMAG J2851, epigyne: c, external and internal (d) view.

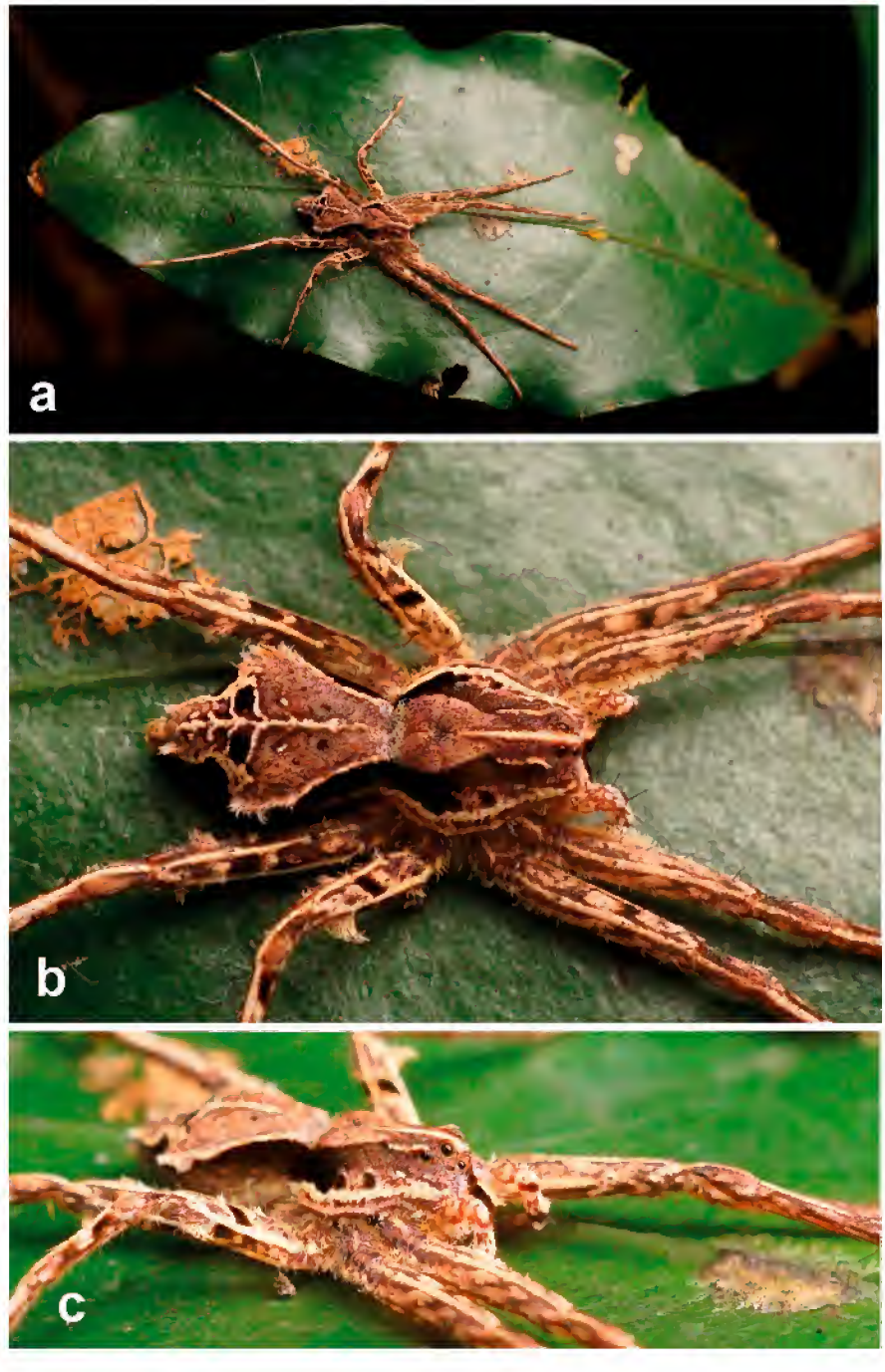


FIG. 44. *Ornodolomedes benrevelli* sp. nov. **a–c,** female, habitus; a, b, dorsal view; c, lateral view. Images, B. Revell.

FIG. 45. *Ornodolomedes benrevelli* sp. nov., different female, habitus. Images, B. Revell.

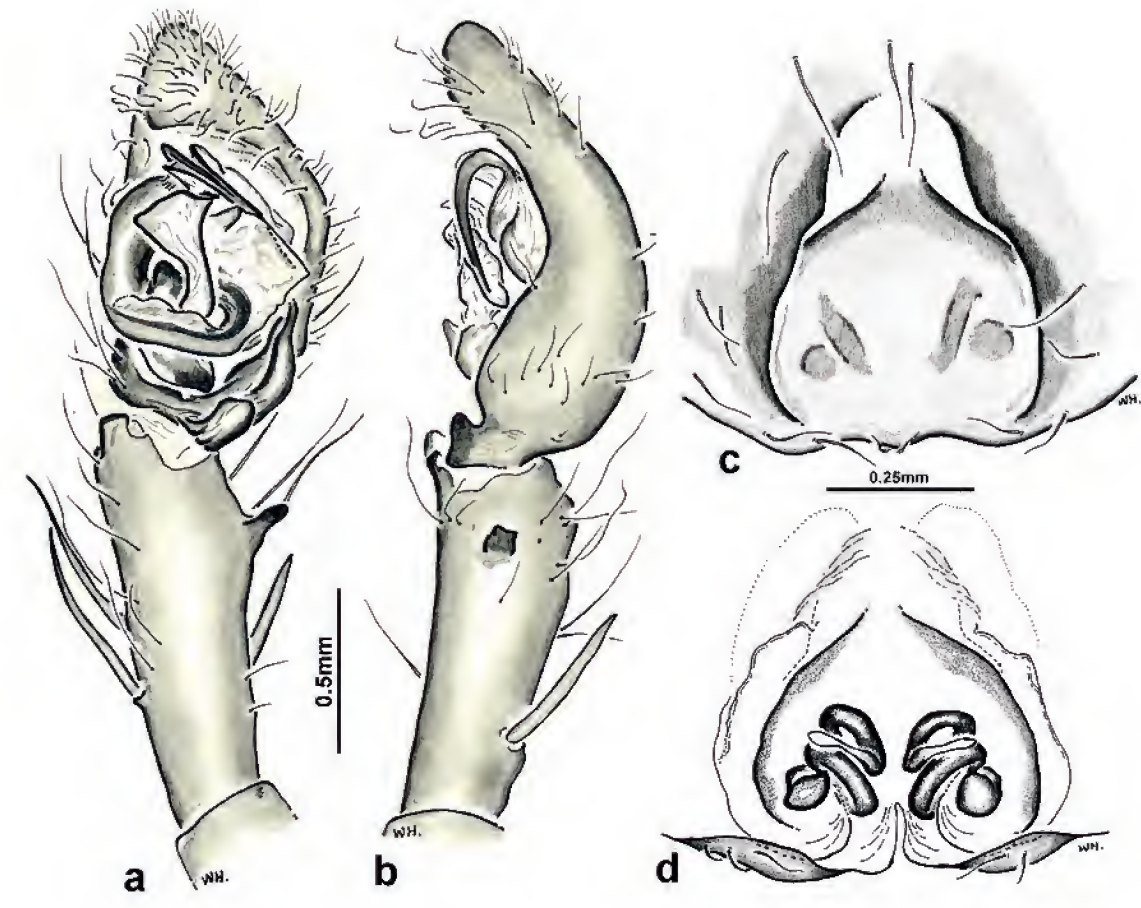


FIG. 46. *Ornodolomedes benrevelli* sp. nov. a, b, holotype male, QM S104920, palpal tibia and cymbium; **a,** ventral view; **b,** retrolateral view. **c, d,** female QM S10496, epigyne: c, external and internal (d) views.

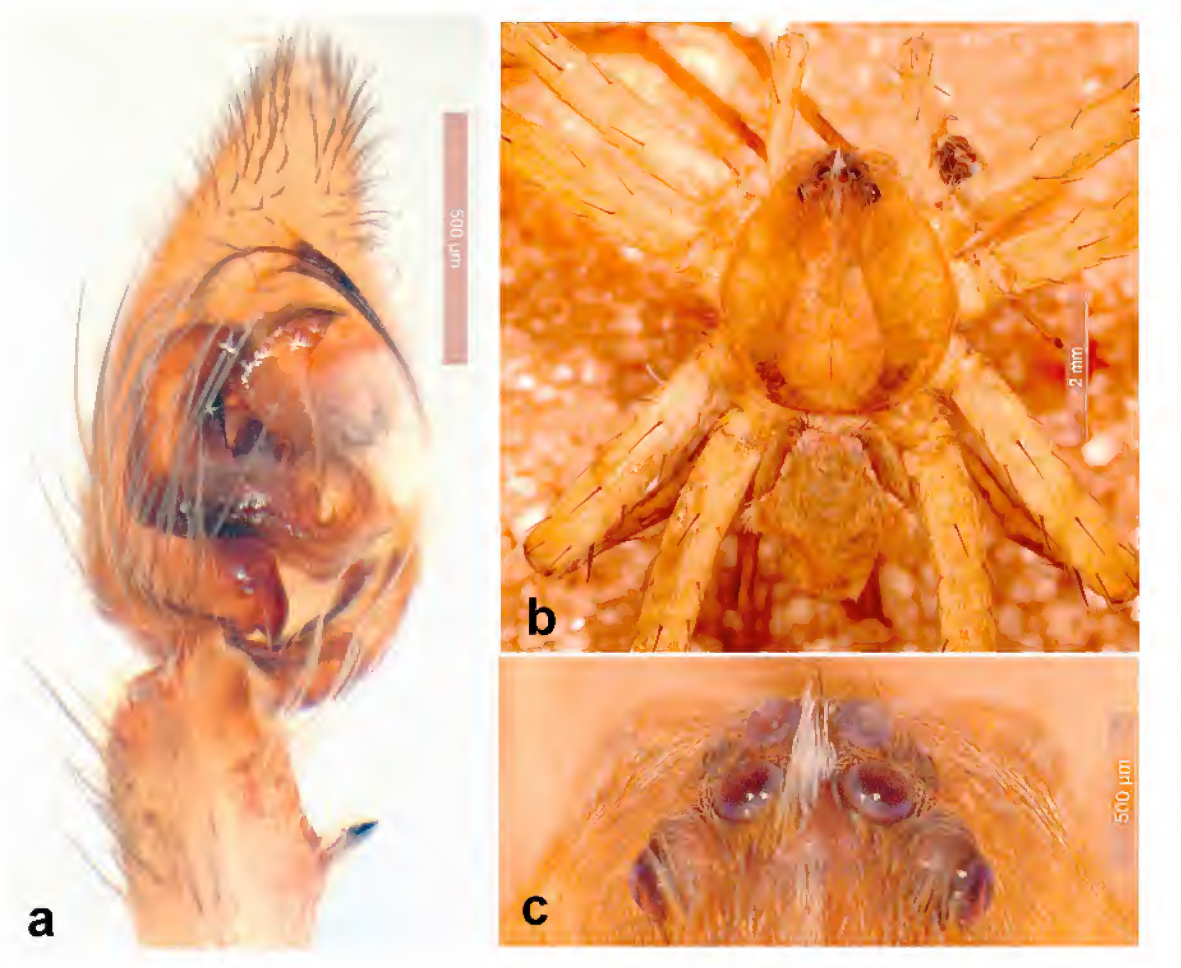


FIG. 47. *Ornodolomedes benrevelli* sp. nov.: **a–c,** holotype male QM S104920. **a,** palpal tibia and cymbium, ventral view; **b,** habitus, dorsal view; **c,** eyes, dorsal view.

FIG. 48. *Ornodolomedes gorenpul* sp. nov. **a,** holotype male, QM S55979, habitus, dorsal view; **b,** female QM S55979, habitus, dorsal view.

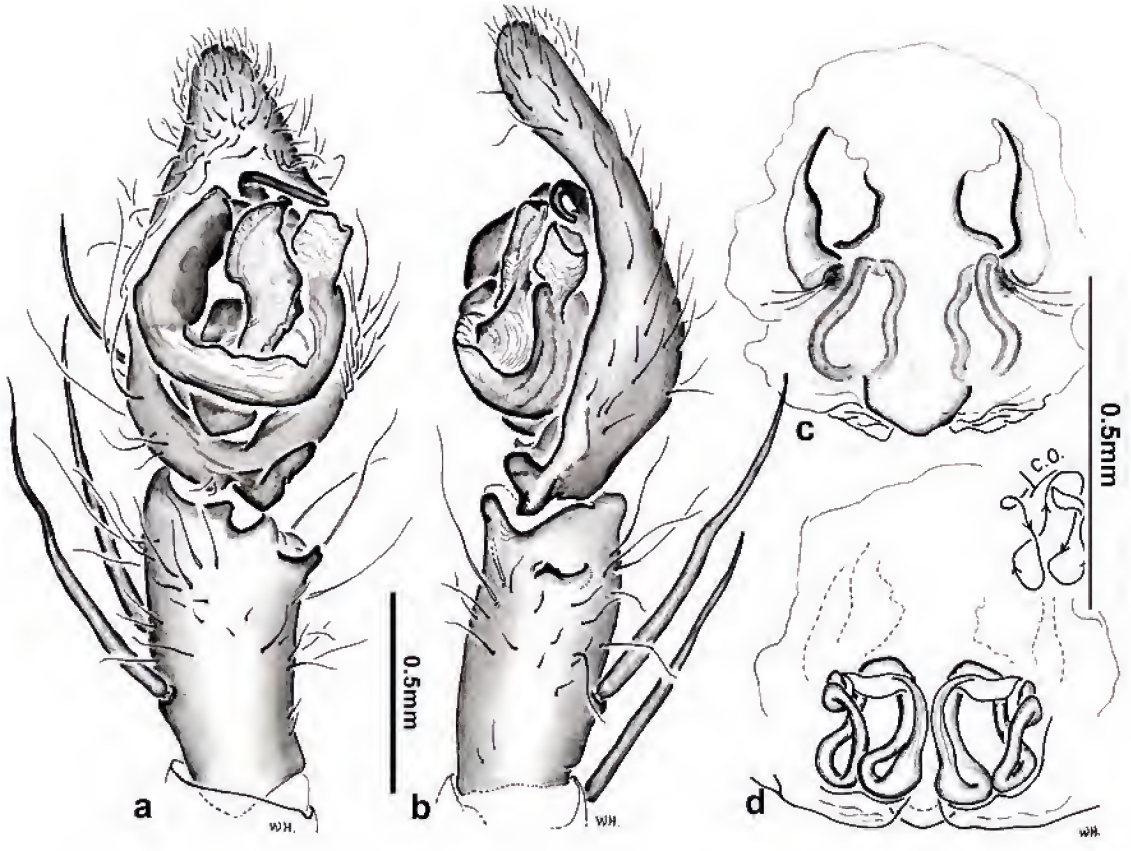


FIG. 49. *Ornodolomedes gorenpul* sp. nov. **a, b,** male QM S55979, palpal tibia and cymbium; **a,** ventral view; **b,** retrolateral view; **c, d,** female QM S108401, epigyne: **c,** external and internal (d) view.

FIG. 50. *Ornodolomedes mickfanningi* sp. nov. **a, c, d,** holotype male, QM S104681; **a,** habitus, dorsal view; **c,** carapace, lateral view; **d,** eyes, dorsal view. **b,** female, habitus, dorsal view.

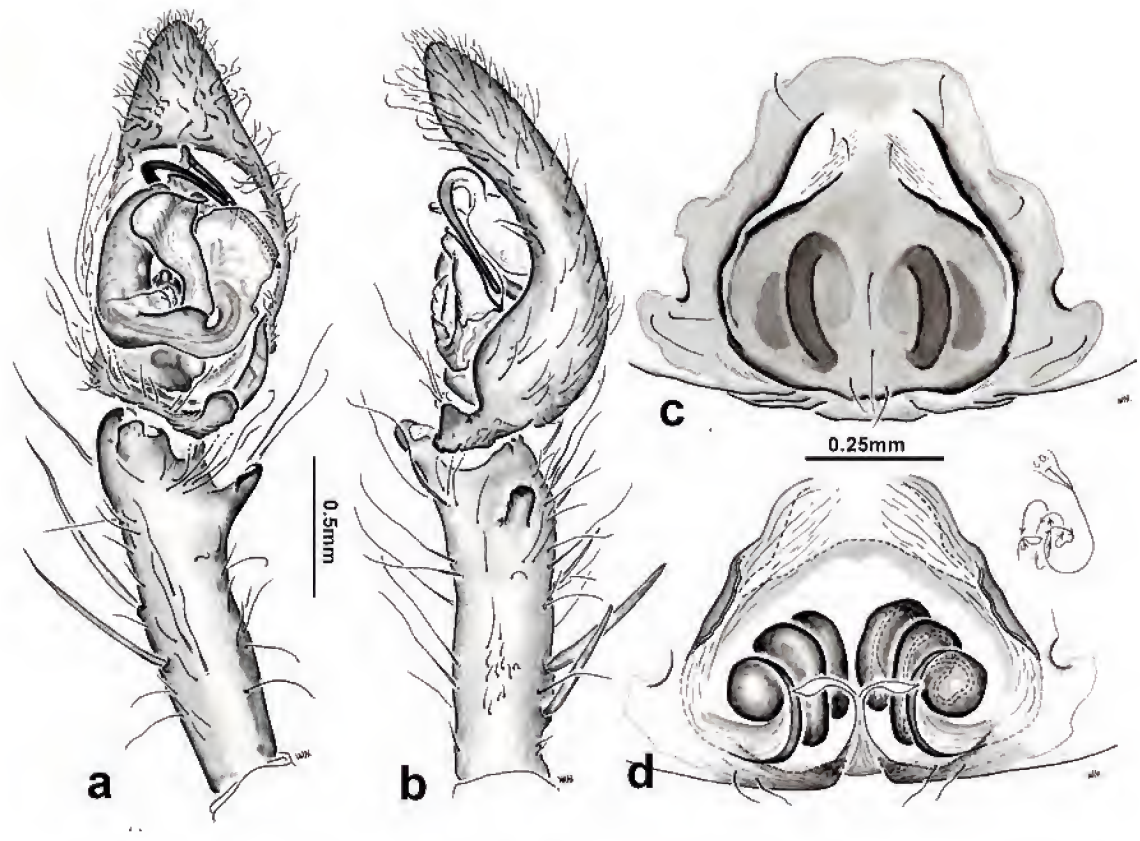


FIG. 51. *Ornodolomedes mickfanningi* sp. nov. **a, b,** holotype male, QM S104681, palpal tibia and cymbium; **a,** ventral view; **b,** retrolateral view. **c, d,** female QM S81158, epigyne: c, external and internal (d) view.

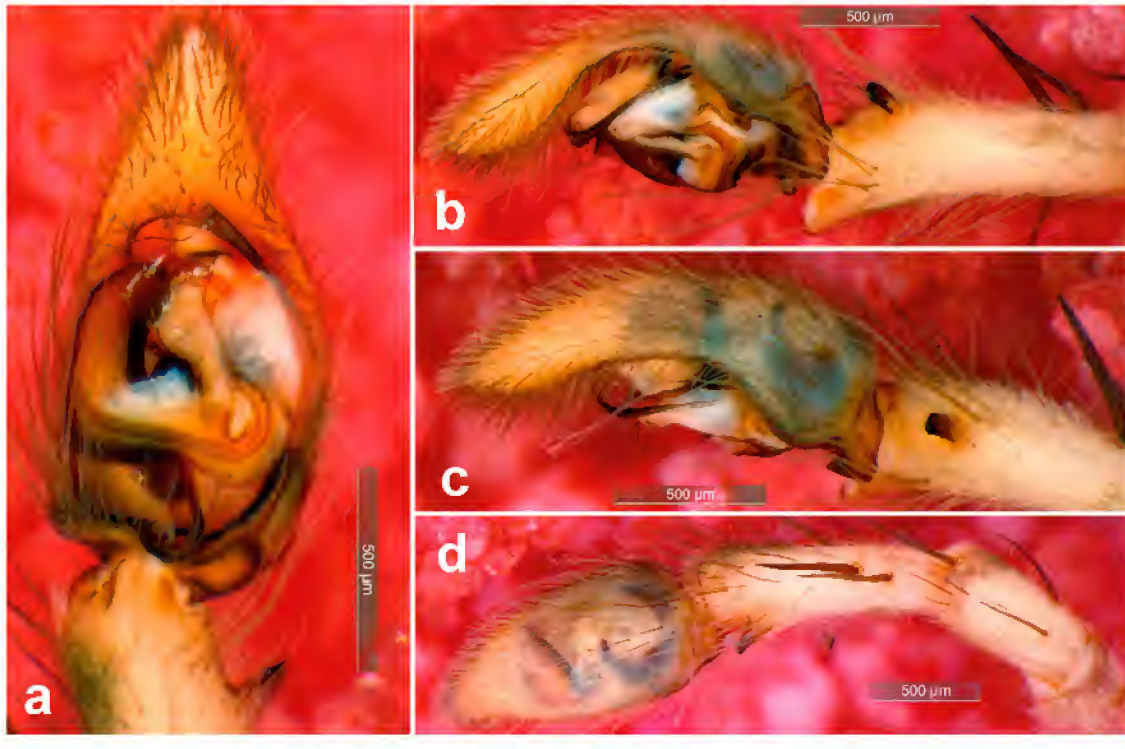


FIG. 52. *Ornodolomedes mickfanningi* sp. nov. **a, b,** holotype male, QM S104681, palpal tibia and cymbium; **a,** ventral view; **b,** retrolateral view, **c,** retrodorsal view; **d,** dorsal view.

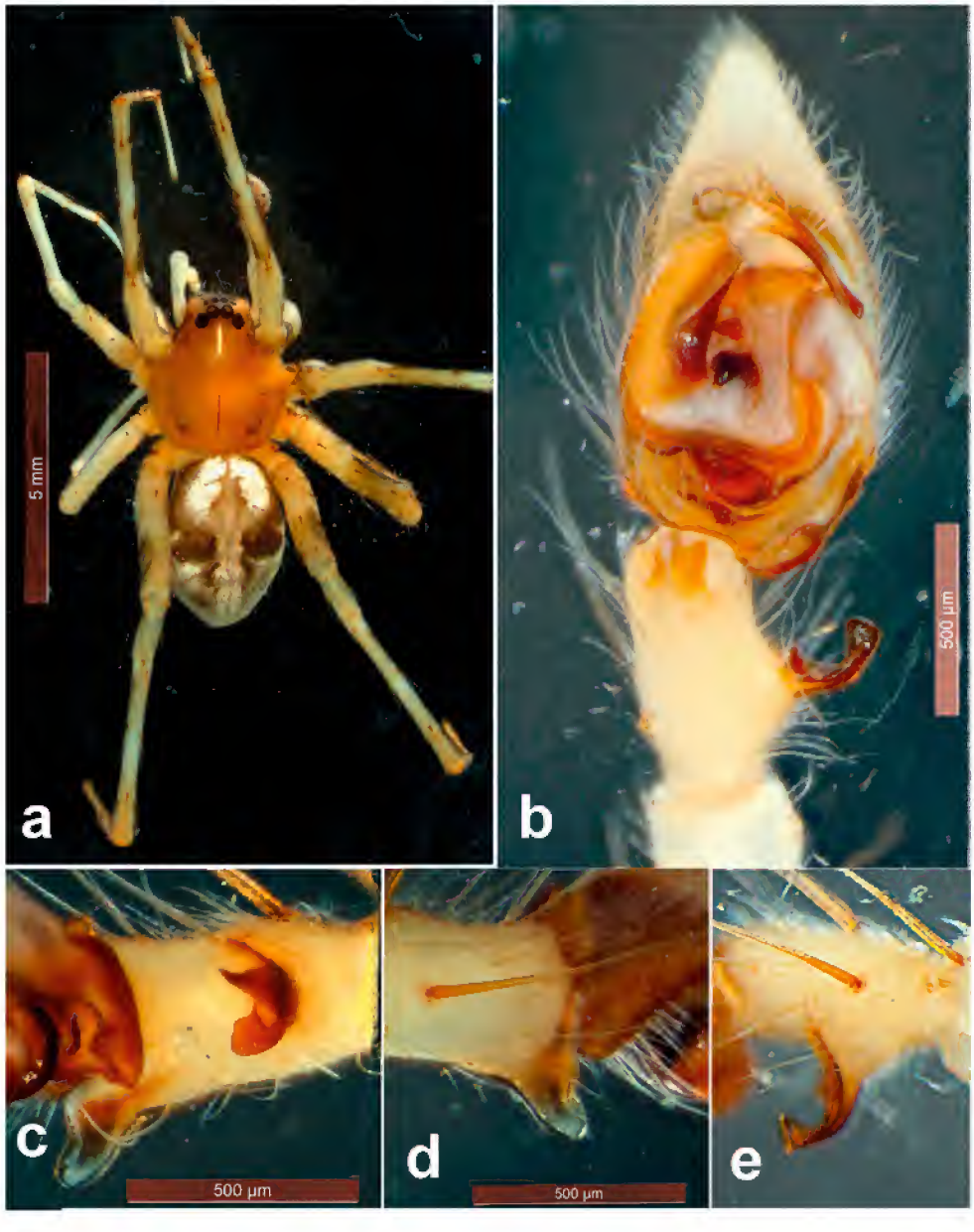


FIG. 53. *Ornodolomedes nebulosus* sp. nov., holotype male, QM S27998. **a,** habitus, dorsal view; **b–e,** palpal tibia and cymbium; **b,** ventral view; **c,** retrolateral view, **d,** prolateral view; **e,** dorsal view.

FIG. 54. *Ornodolomedes yalangi* sp. nov., holotype male QM S59162. **a–c, f,** palpal tibia and cymbium; **a,** ventral view; **b,** retrolateral view; **c,** prolateral view; **f,** retrolateral view showing full tibia; **d,** habitus, dorsal view; prolateral view; **e,** eyes, dorsal view; **g,** eyes, face.

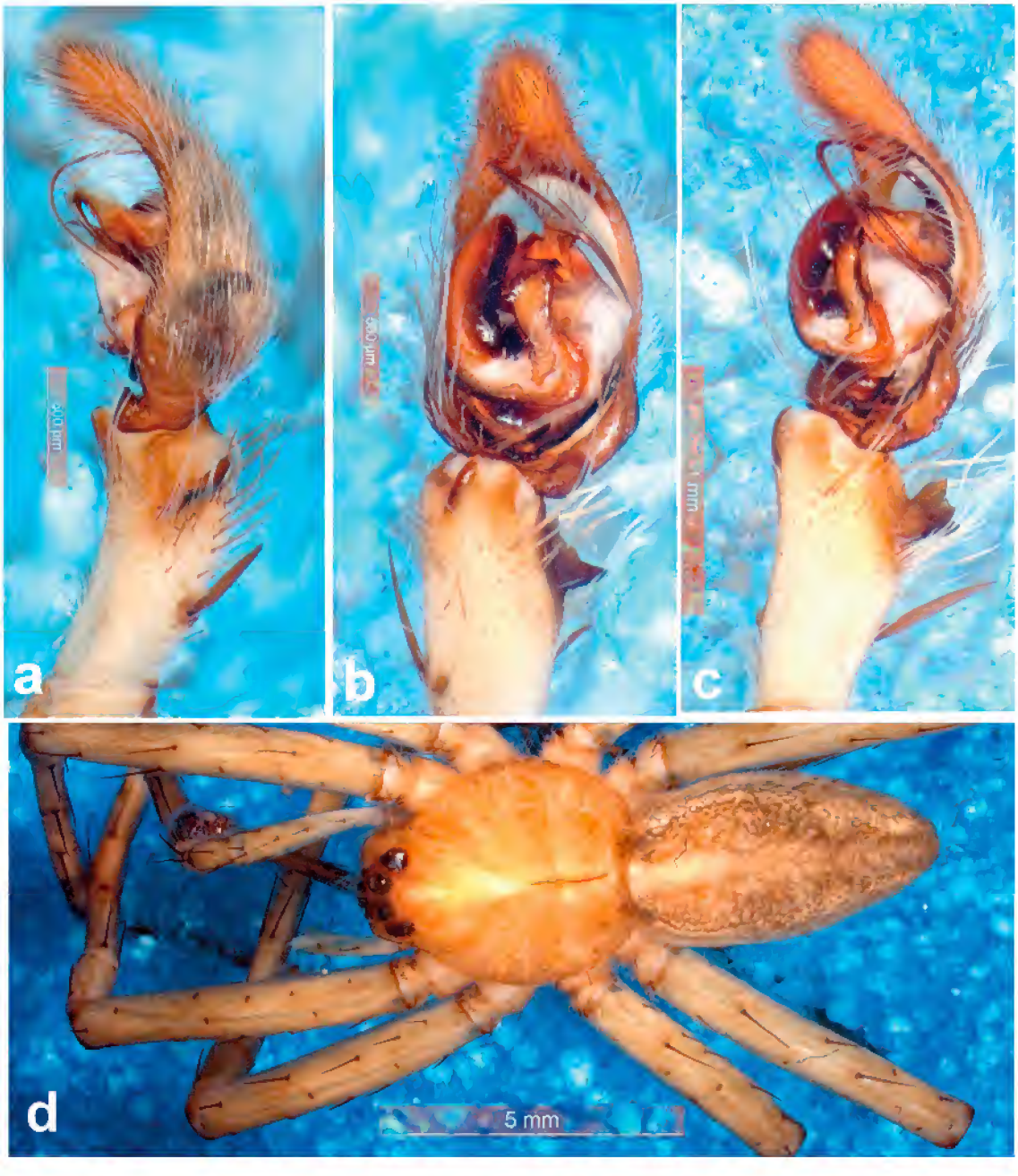


FIG. 55. *Ornodolomedes starickí* sp. nov., holotype male ANIC 42-002259. **a–c,** palpal tibia and cymbium; a, retrolateral view; **b,** ventral view; **c,** retrodorsal view; **d,** habitus, dorsal view.

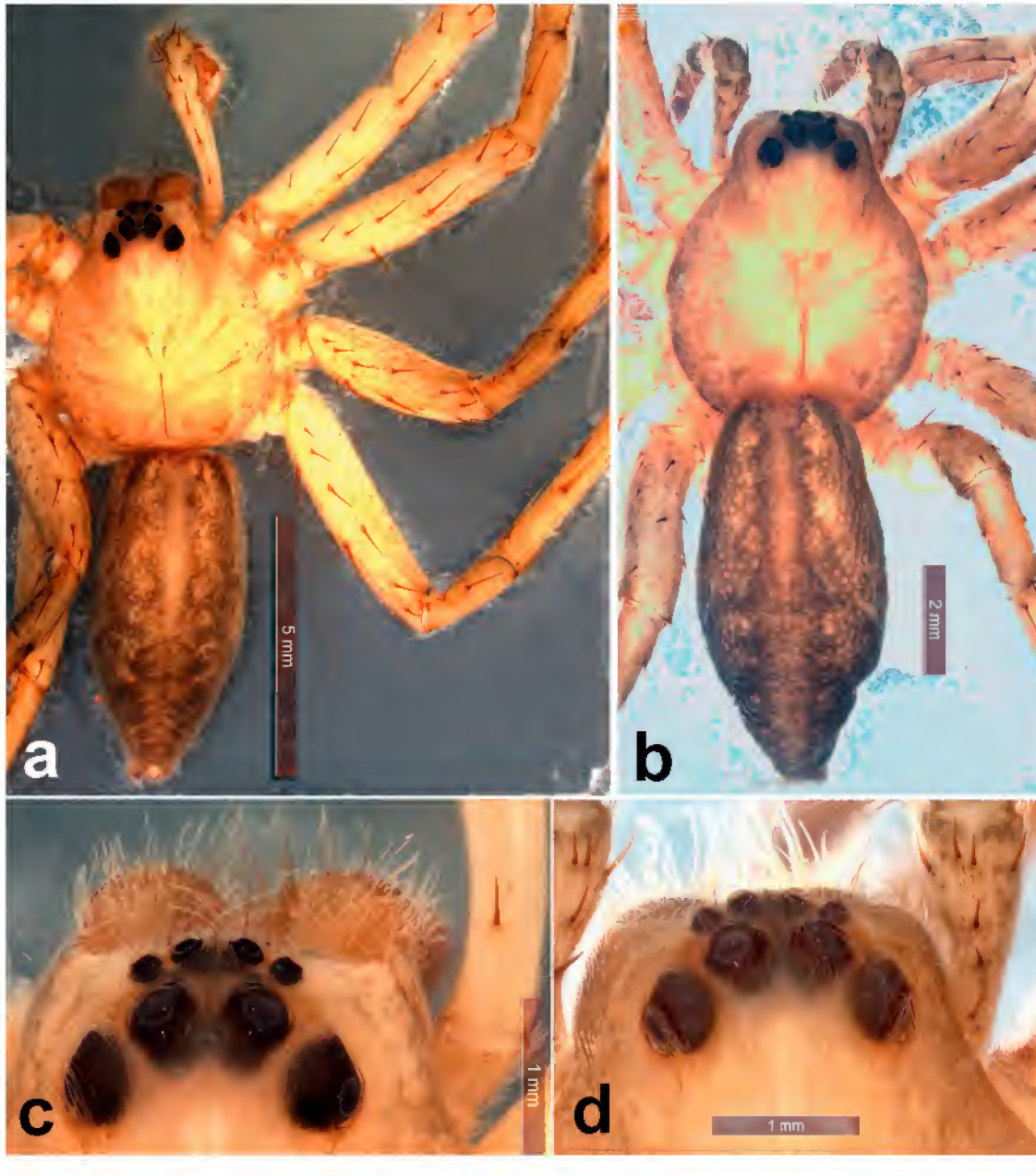


FIG. 56. *Ornodolomedes southcotti* sp. nov., holotype SAMA NN1997939, male. **a,** habitus, dorsal view; **c,** eyes, dorsal view; SAMA NN1997940, penult. female: **b,** habitus, dorsal view; **d,** eyes, dorsal view.

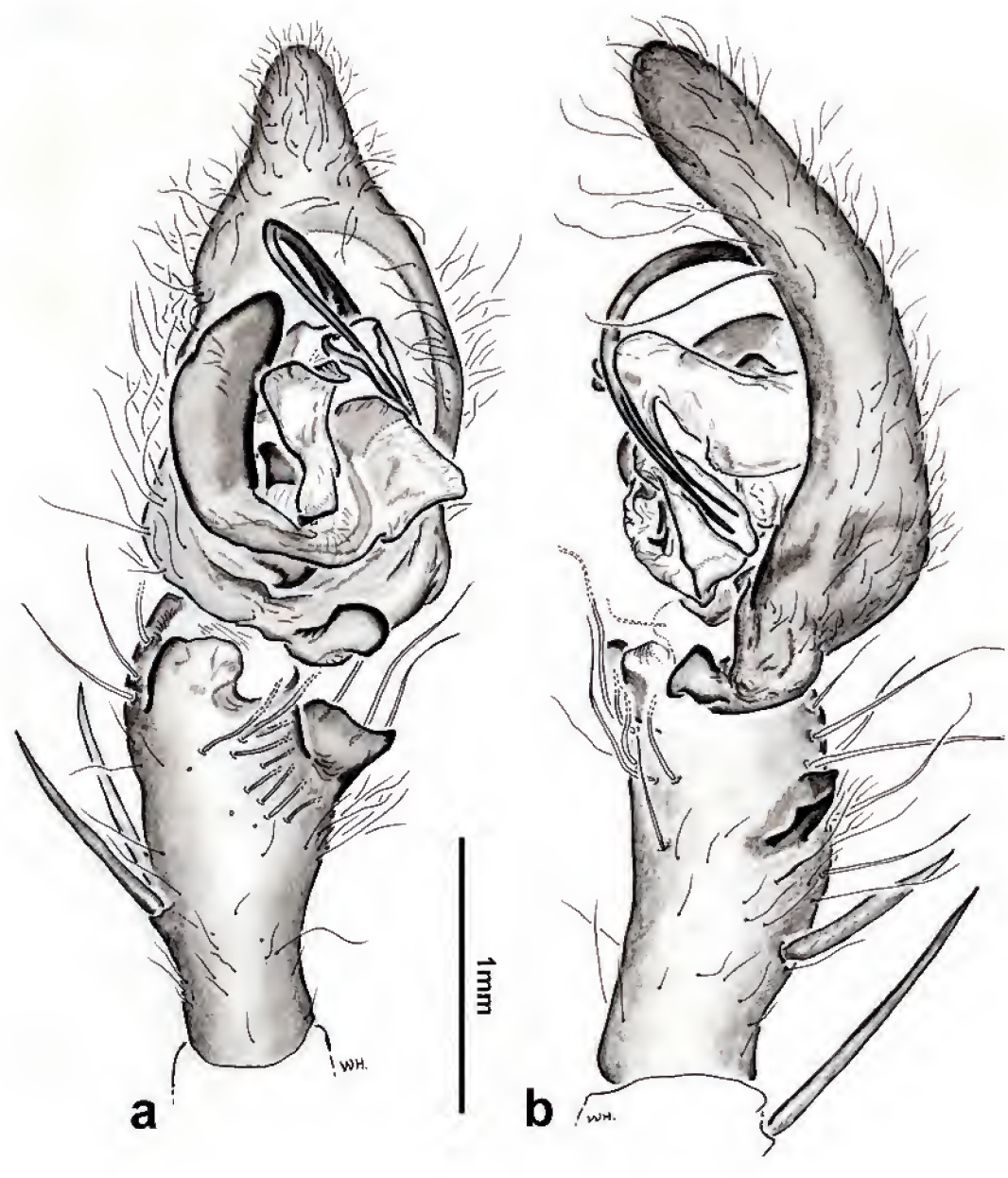


FIG. 57. *Ornodolomedes southcotti* sp. nov., holotype SAMA N1997939, male. **a, b,** palpal tibia and cymbium; **a,** ventral view; **b,** retrolateral view.

FIG. 58. *Ornodolomedes nicholsoni* sp. nov., habitus, dorsal view. **a,** holotype WAM T75675; **b,** male WAM 111262; **c, d,** Glenbourne, WAM T111341; **c,** male, dorsal view; **d,** female, dorsal view.

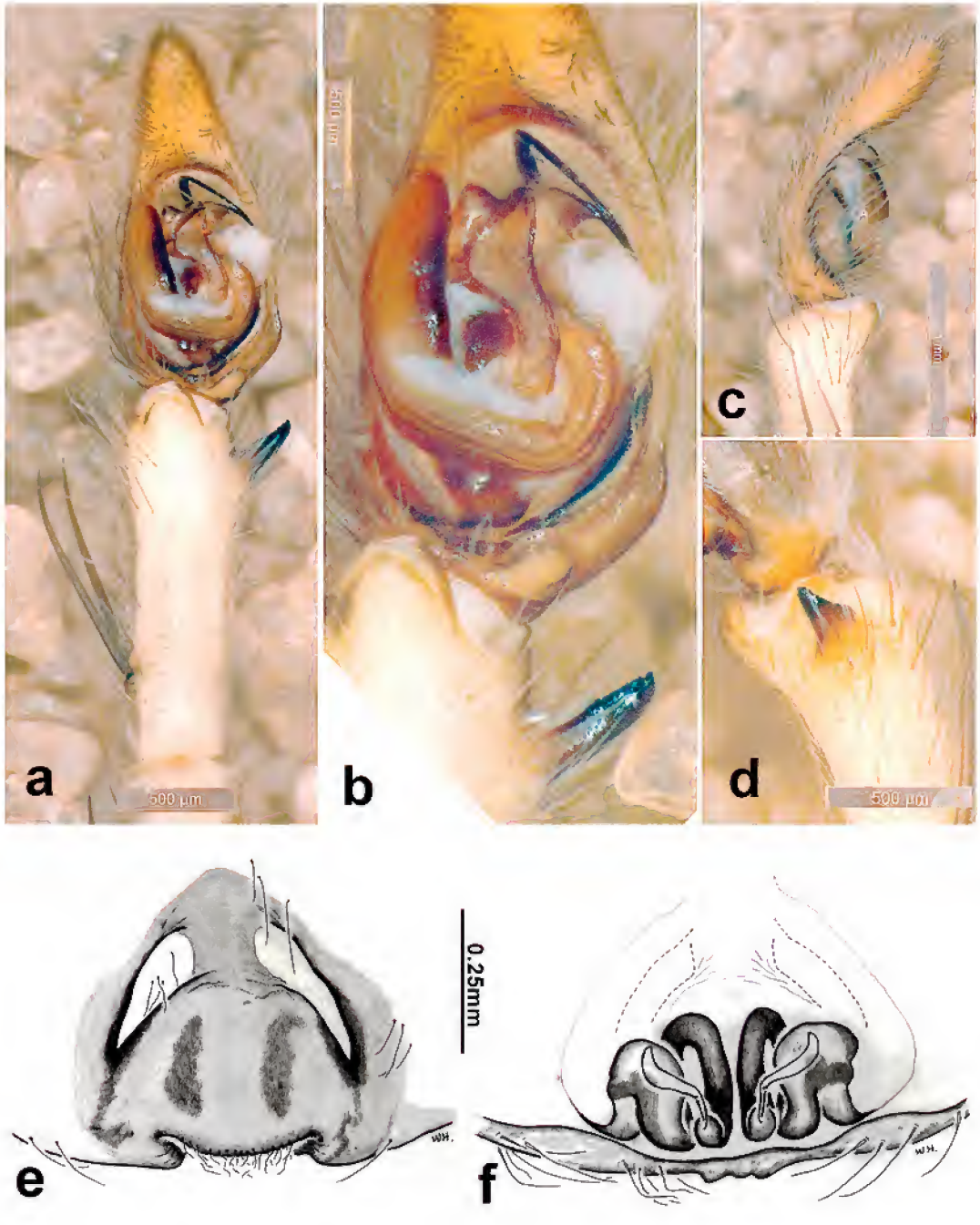


FIG. 59. *Ornodolomedes nicholsoni* sp. nov. **a–d,** holotype WAM T75675, palpal tibia and cymbium; **a, b,** ventral view; **c,** prolateral view; **d,** retrolateral view. **e, f,** female WAM T111341, epigyne: **e,** external and internal (f) view.

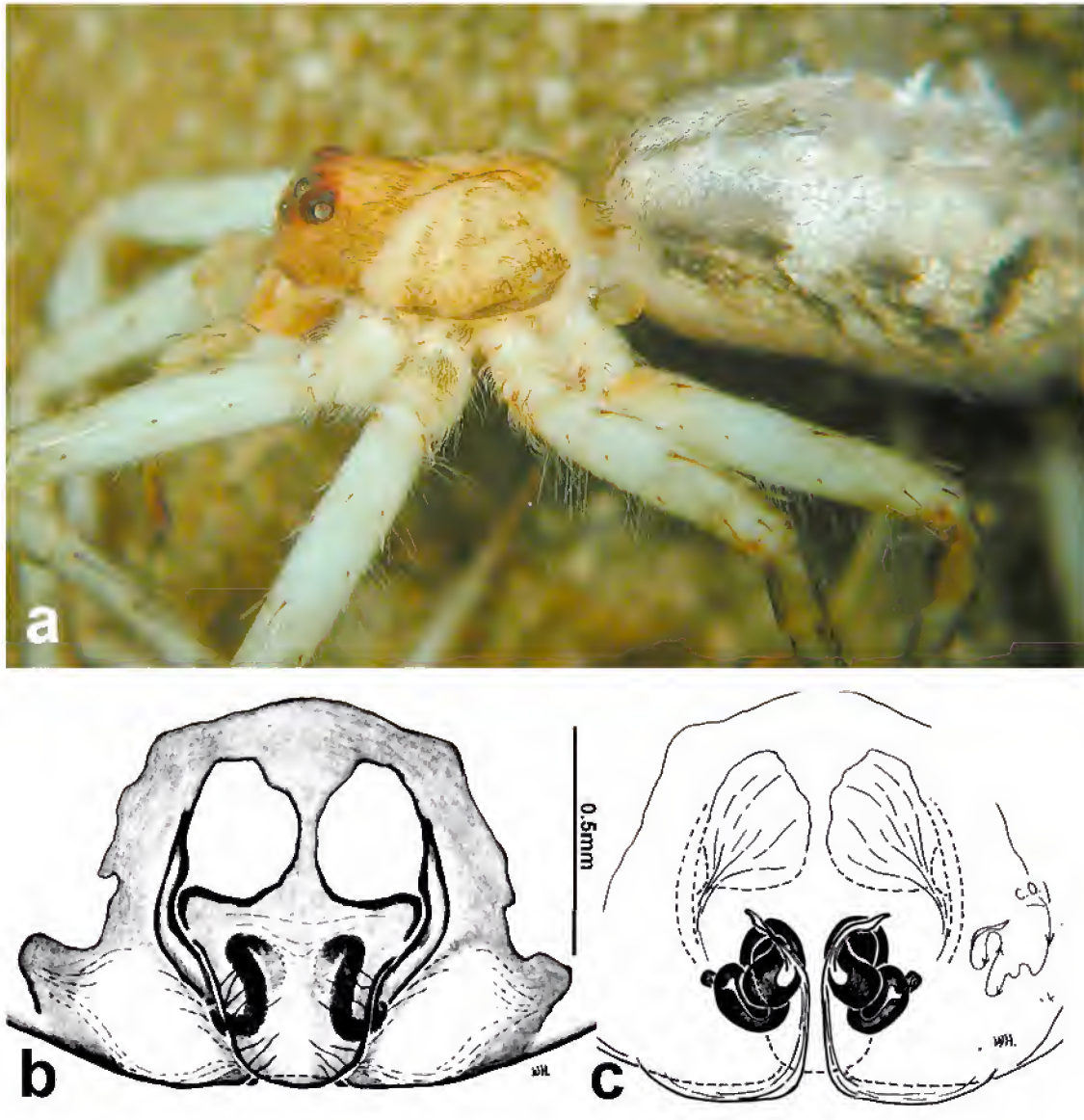


FIG. 60. *Ornodolomedes xypee* sp. nov. **a–c,** holotype female QM S86872; **a,** habitus, lateral view; **b, c,** epigyne: **b,** external and internal (c) view.

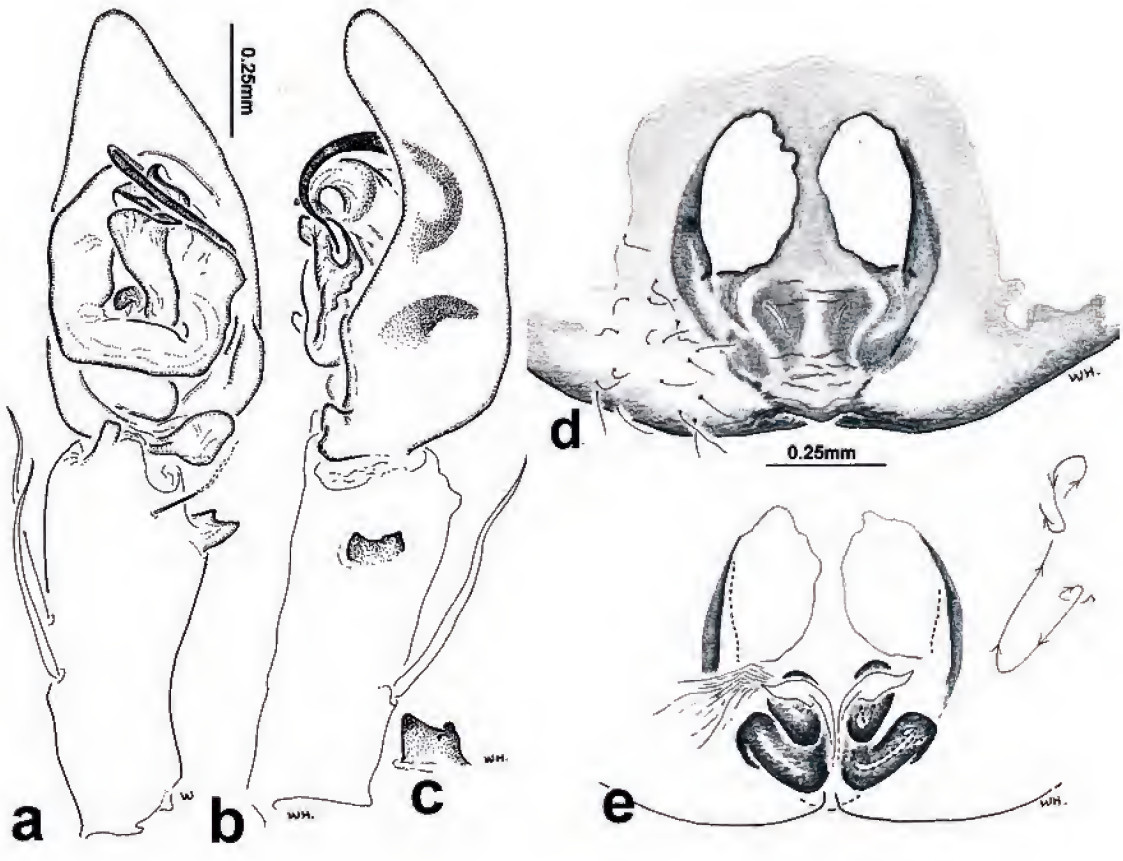


FIG. 61. *Ornodolomedes marshi* sp. nov. **a–c,** holotype male QM S28805; **a, b,** palpal tibia and cymbium; **a,** ventral view; **b,** retrolateral view; **c,** retrolateral tibial apophysis, RTAmax view. *Ornodolomedes nebulosus* sp. nov., female AM KS103149, **d, e,** epigyne: **d,** external and internal, showing path of ducts (e) view.

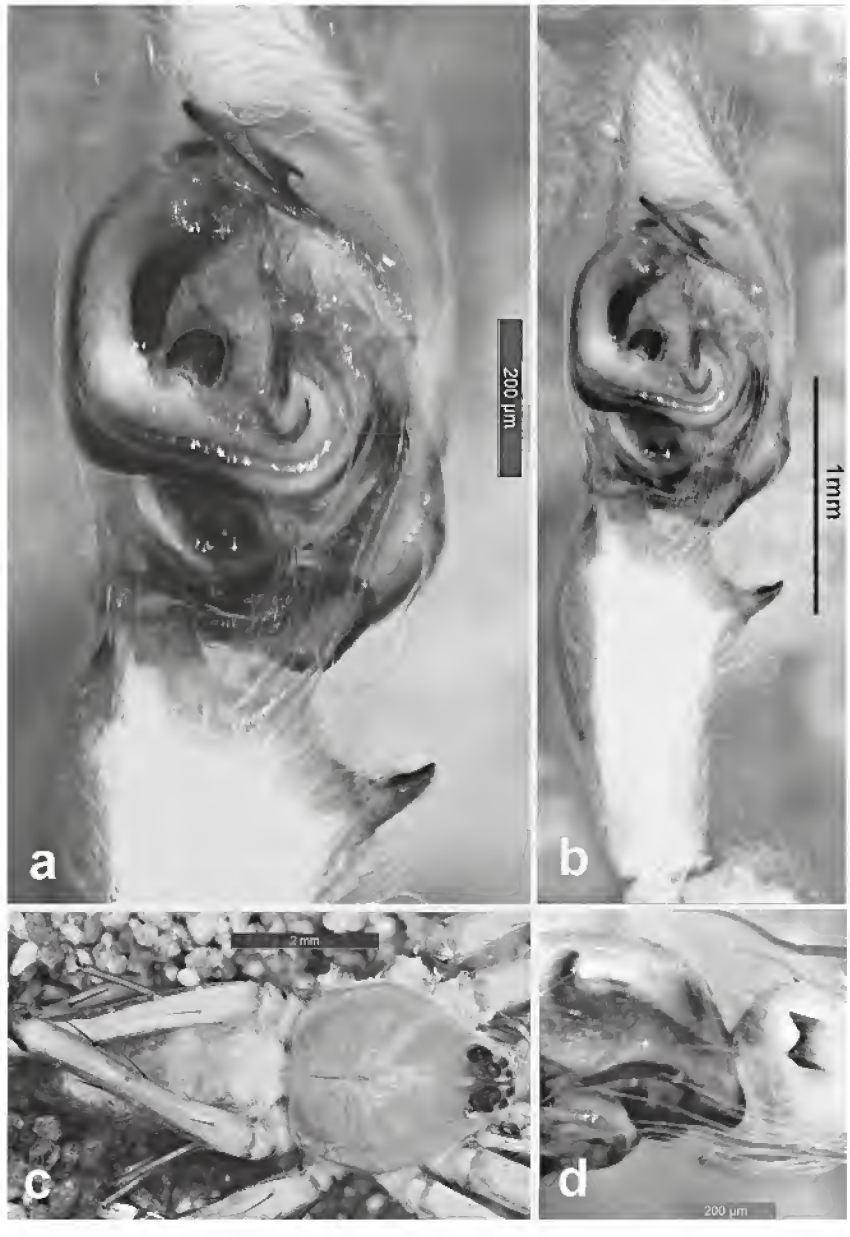


FIG. 62. *Ornodolomedes marshi* sp. nov. a–d, holotype male QM S28805; **a, b, d,** palpal tibia and cymbium; **a, b,** ventral view; **c,** habitus; dorsal view; **d,** RTAMax view.

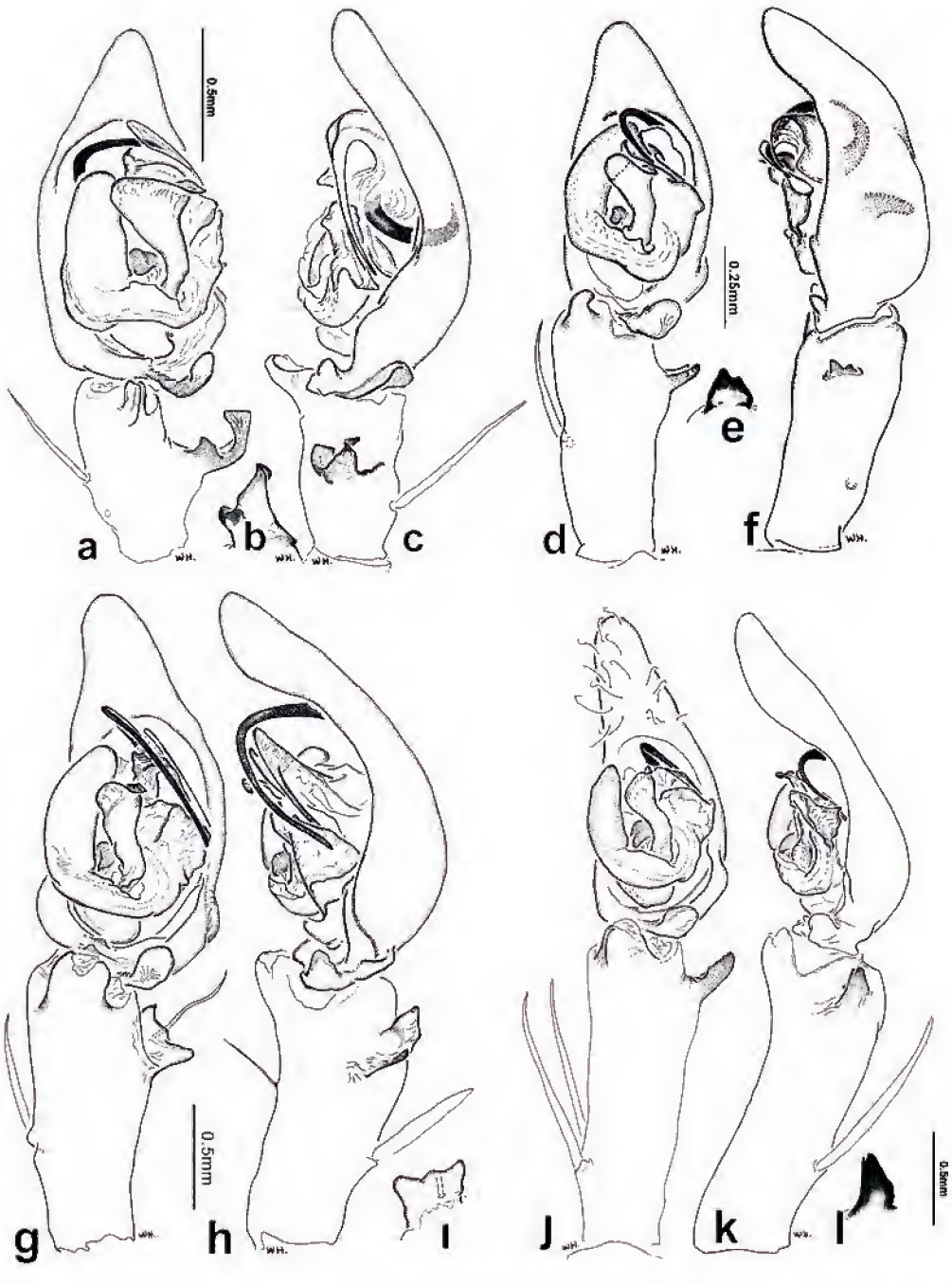


FIG. 63. *Ornodolomedes*, male palpal tibia, cymbium and bulb, with RTA, holotypes. **a–c,** *O. nebulosus*, (mirrored), **a,** ventral view; **b,** retrolateral view; **c,** RTA in RTAmax view; **d–f,** *O. yalangi*, **d,** ventral view; **e,** retrolateral view; **f,** RTA in RTAmax view; **g–i,** *O. staricki*, **g,** ventral view; **h,** retrolateral view; **i,** RTA in RTAmax view; **j–l,** *O. nicholsoni*, **j,** ventral view; **k,** retrolateral view; **l,** RTA in RTAmax view.

FIG. 64. *Mangromedes kochi* (Roewer, 1951). **a,** male, habitus on mangrove, dorsal view; **b,** female QM S14041, habitus, dorsal view; **c, d,** mangroves on foreshore at Wynnum, south-east Queensland, the spiders are most common on the dark "sock" and to a lesser extent on the mud.

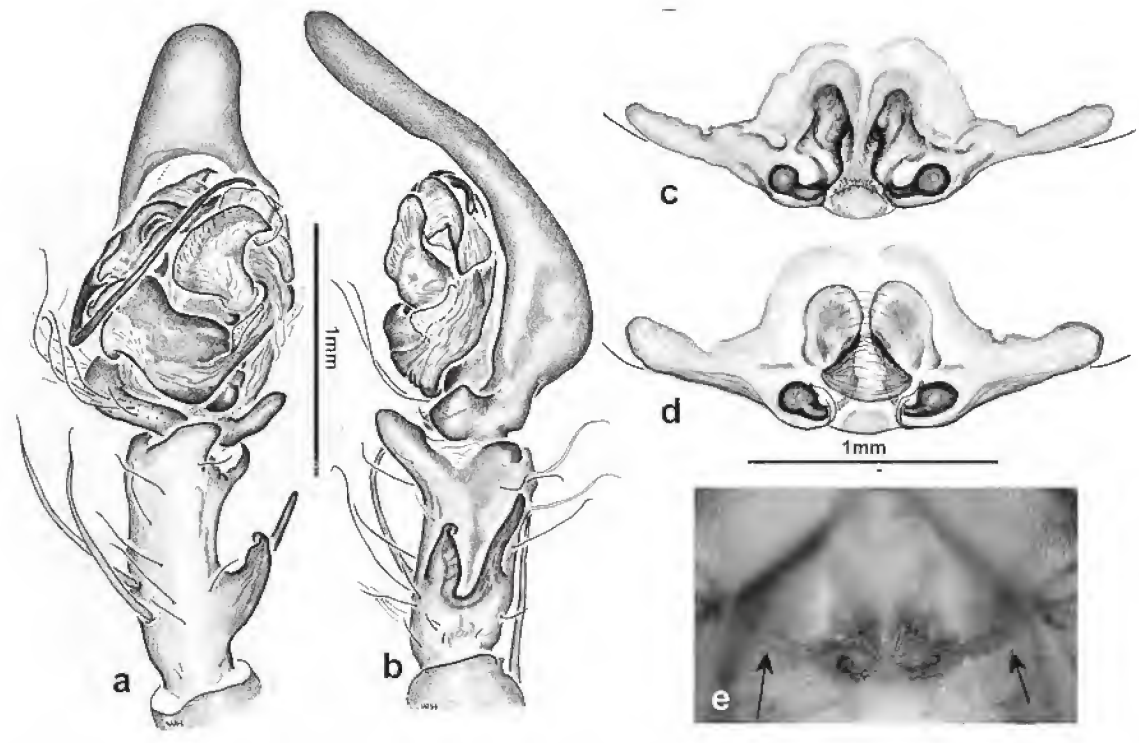


FIG. 65. *Mangromedes kochi* (Roewer, 1951). **a, b,** male QM S34613, palpal tibia and cymbium, mirrored; **a,** ventral iew; **b,** retrolateral view; **c–e,** female QM S14041 epigyne; **c,** external view; **d,** internal view; **e,** genital region showing extent of "wings" (arrows) on venter, ventral view.

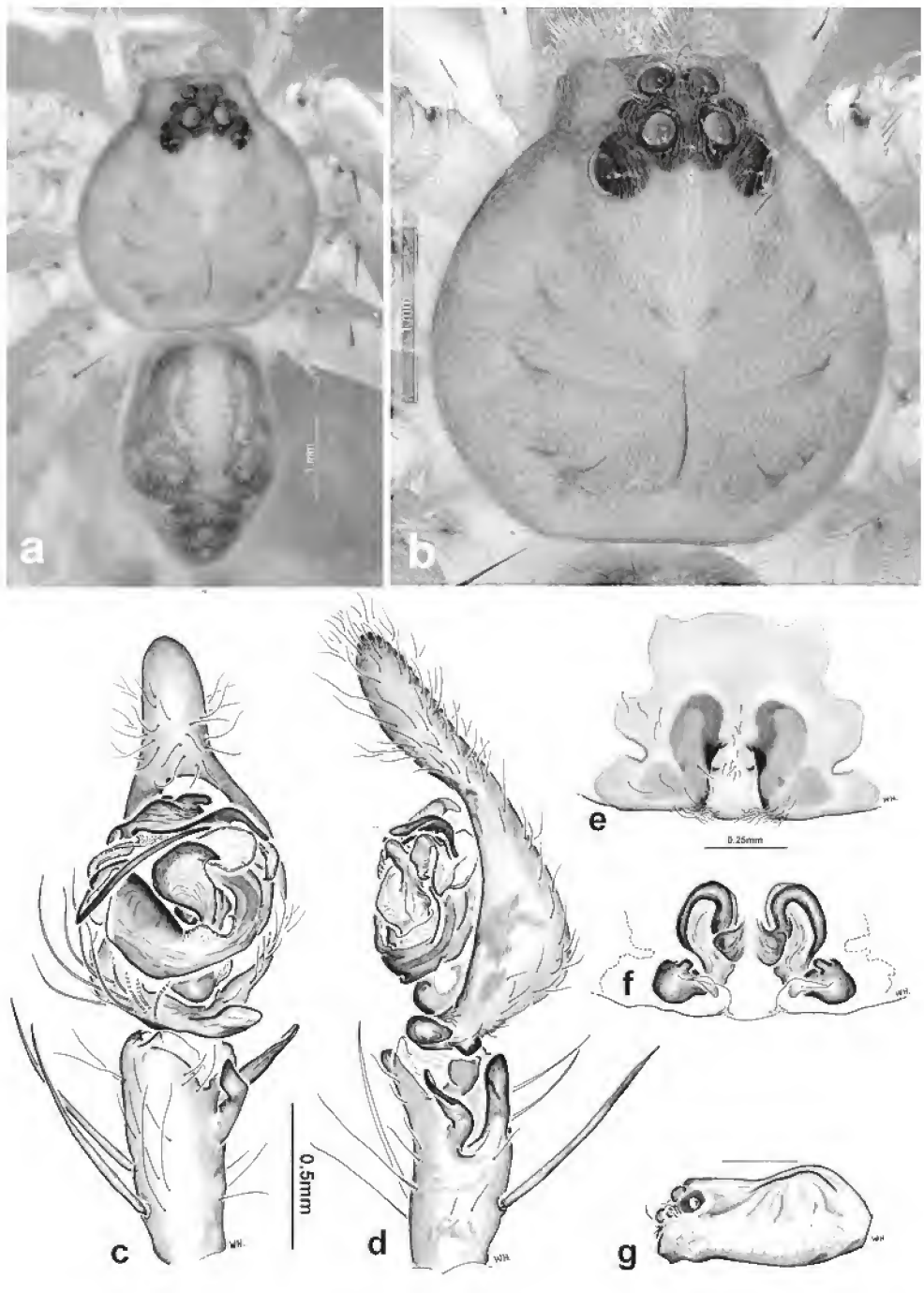


FIG. 66. *Mangromedes porosus* sp. nov., holotype male, MAGNT A004618, **a, b,** habitus, dorsal view; **c, d,** palpal tibia and cymbium; **c,** ventral view; **d,** retrolateral view; **e, f,** epigyne, external (e), internal (f) view, **g,** habitus, lateral view.

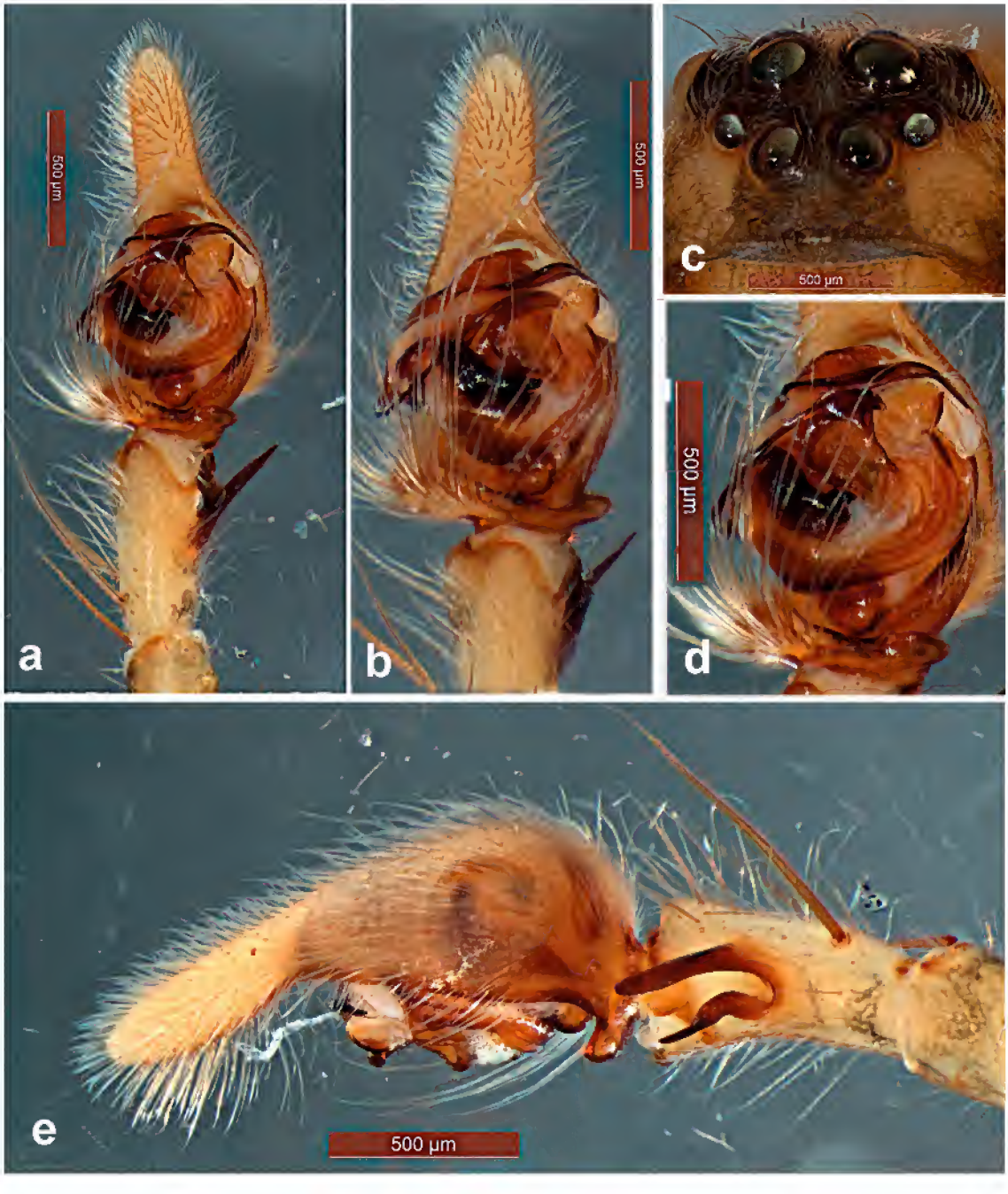


FIG. 67. *Mangromedes porosus* sp. nov., holotype male, MAGNT. **a, b d, e,** palpal tibia and cymbium; **a,** retroventral view; **b, d,** ventral view; **c,** face; **e,** retrolateral view.

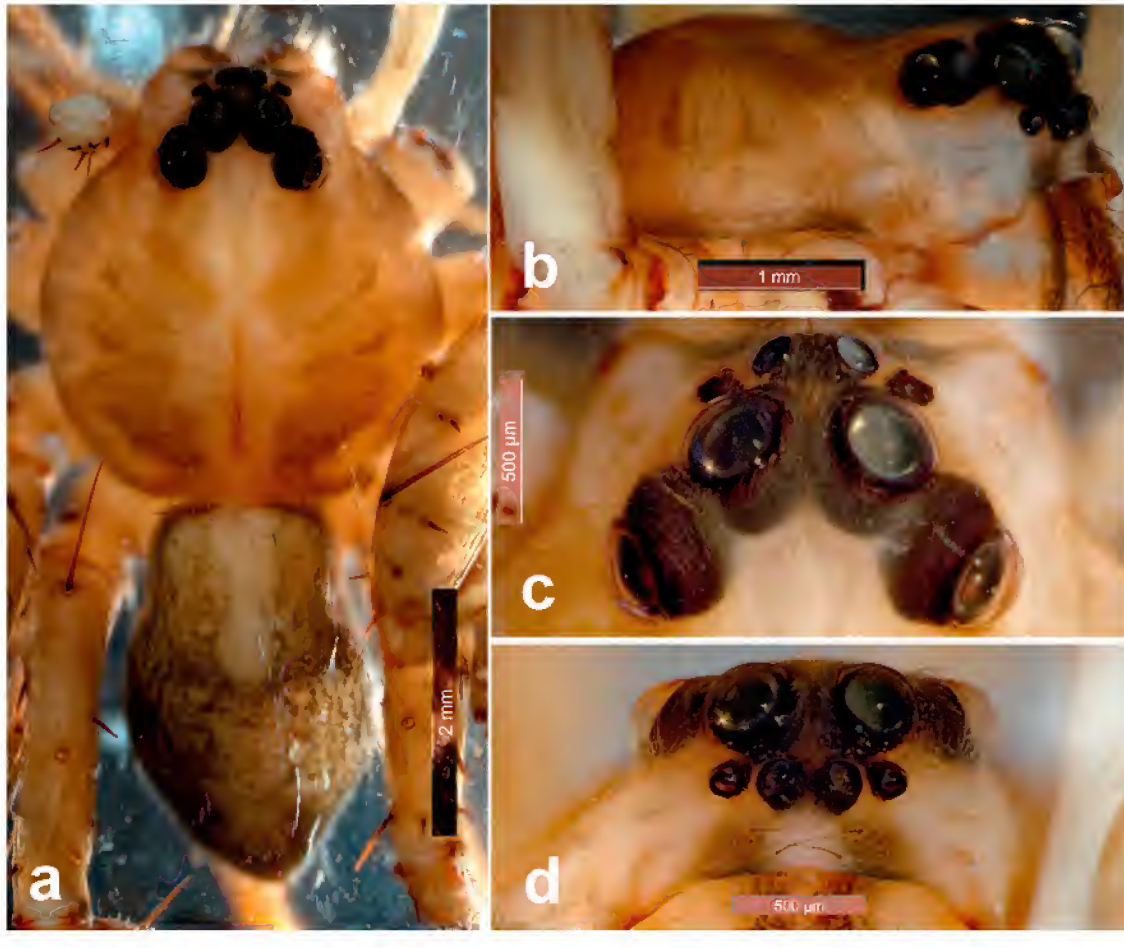


FIG. 68. *Caledomedes flavovittatus* (Simon, 1880), male, QM S108411. **a,** habitus, dorsal view; **b,** carapace, lateral view; **c,** eyes, dorsal view; **d,** face.

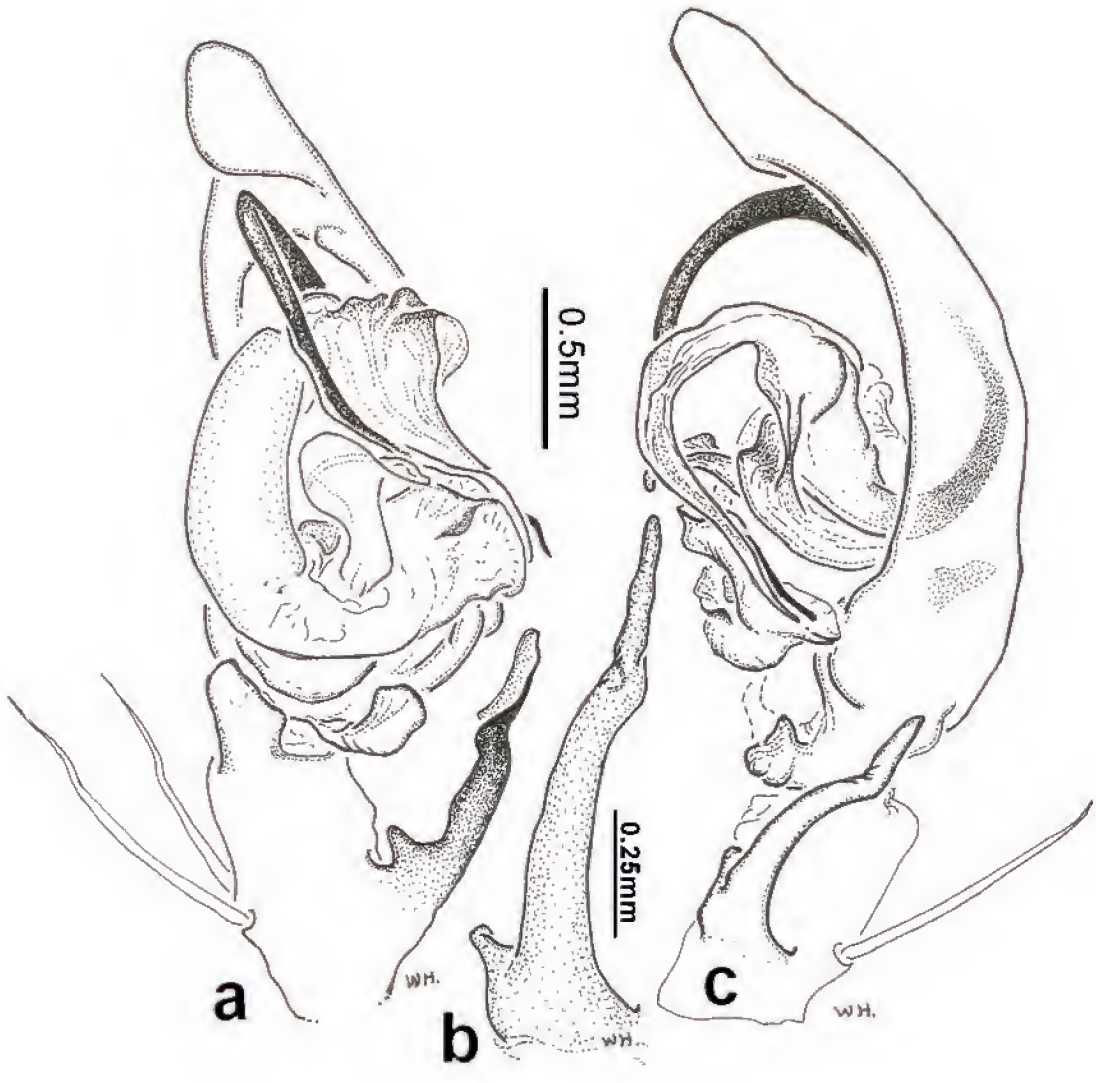


FIG. 69. *Caledomedes flavovittatus* (Simon, 1880), male, QM S108411. **a, b,** male palpal tibia and cymbium; **a,** ventral view; **b,** RTAmax view; **c,** retrolateral view.

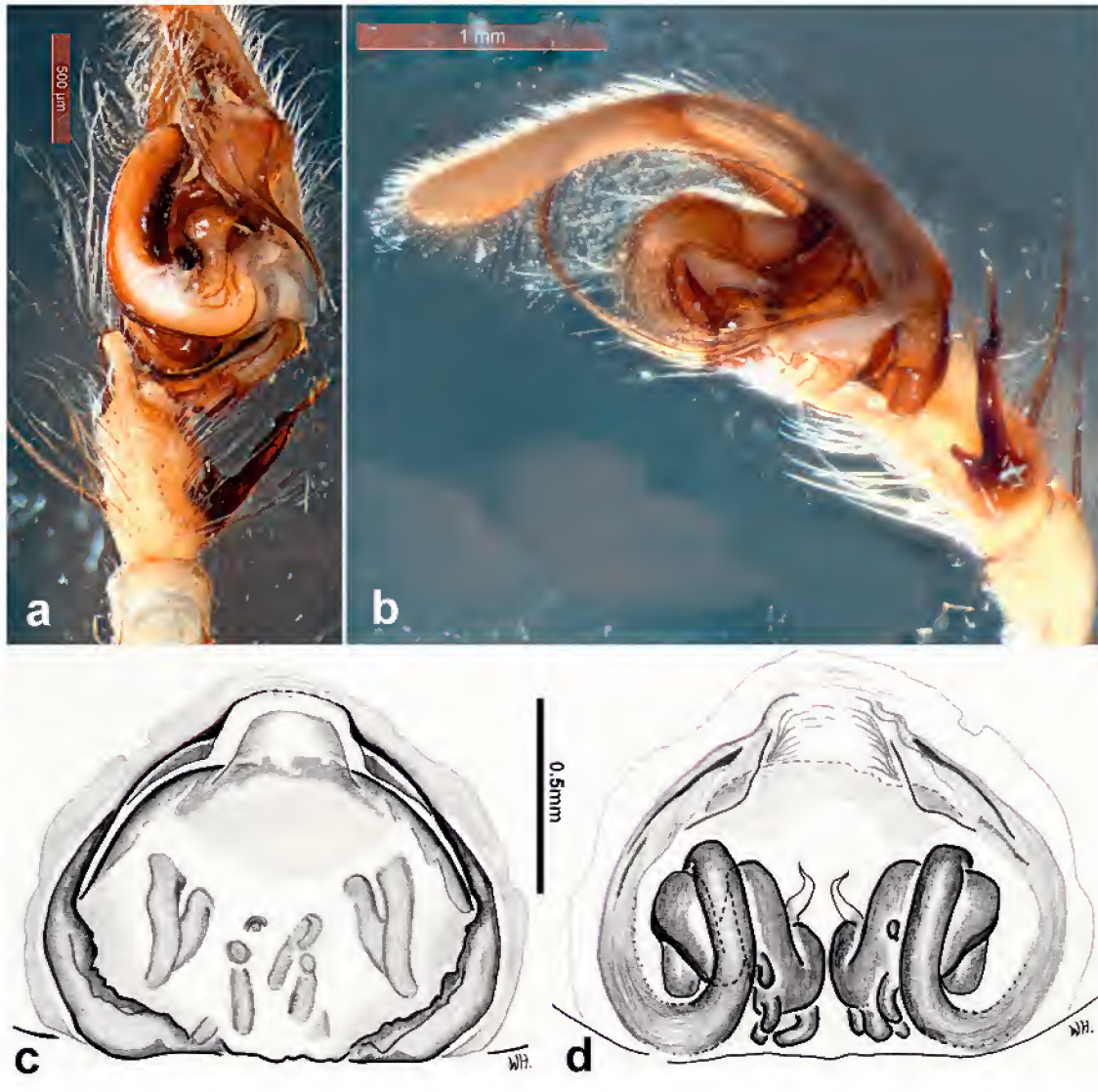


FIG. 70. *Caledomedes flavovittatus* (Simon, 1880). Male, QM S108411. **a, b,** male palpal patella, tibia and cymbium; **a,** ventral view; **b,** retrolateral view; **c, d,** epigyne QM S67859; external (c) and internal (d) views.

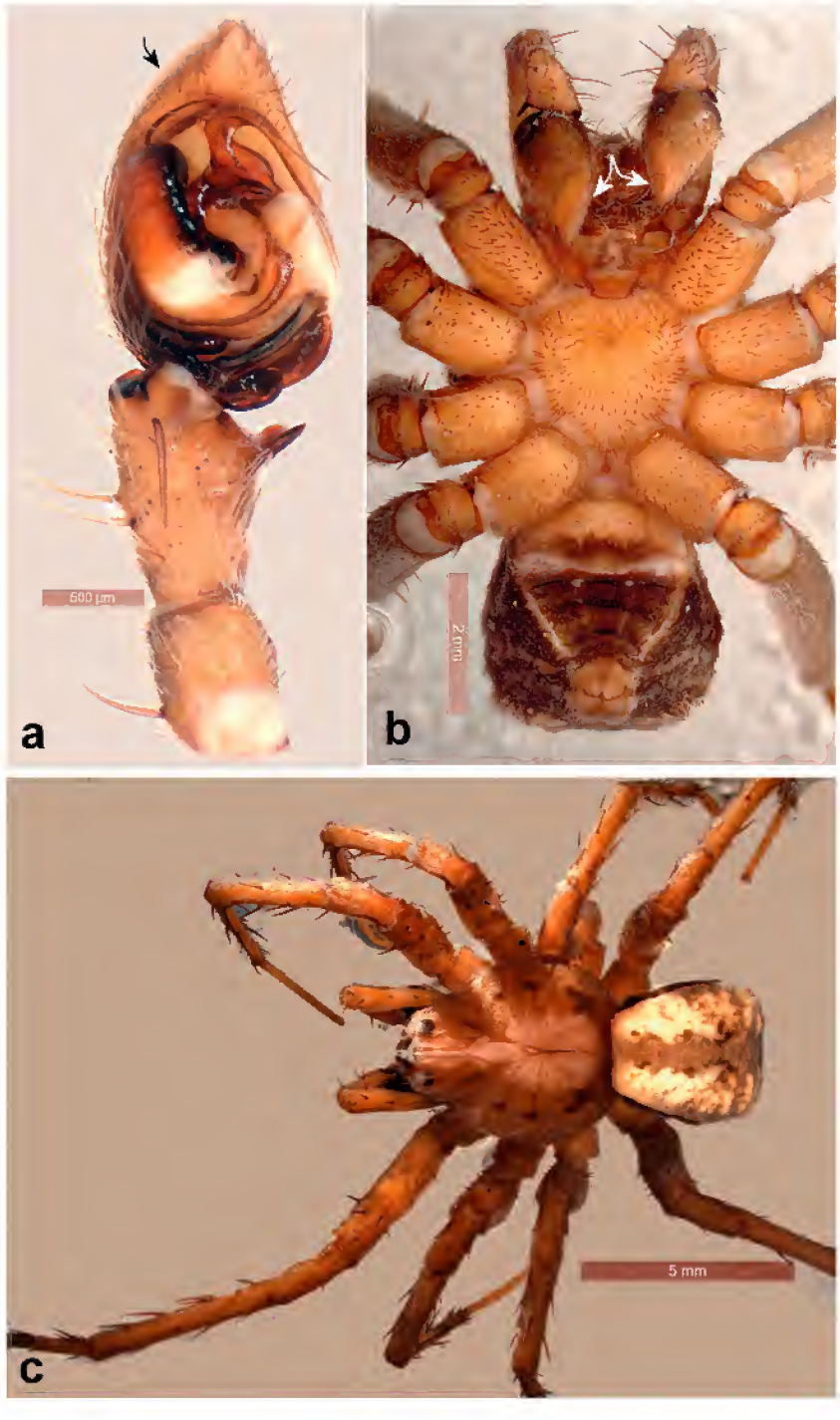


FIG. 71. *Bradystichus calligaster* Simon, 1884, male, QM S25653. **a,** palpal patella, tibia and cymbium, ventral view, showing scopula (arrow); **b,** venter, showing scopula on ental cymbium edge; **c,** habitus, dorsal view.

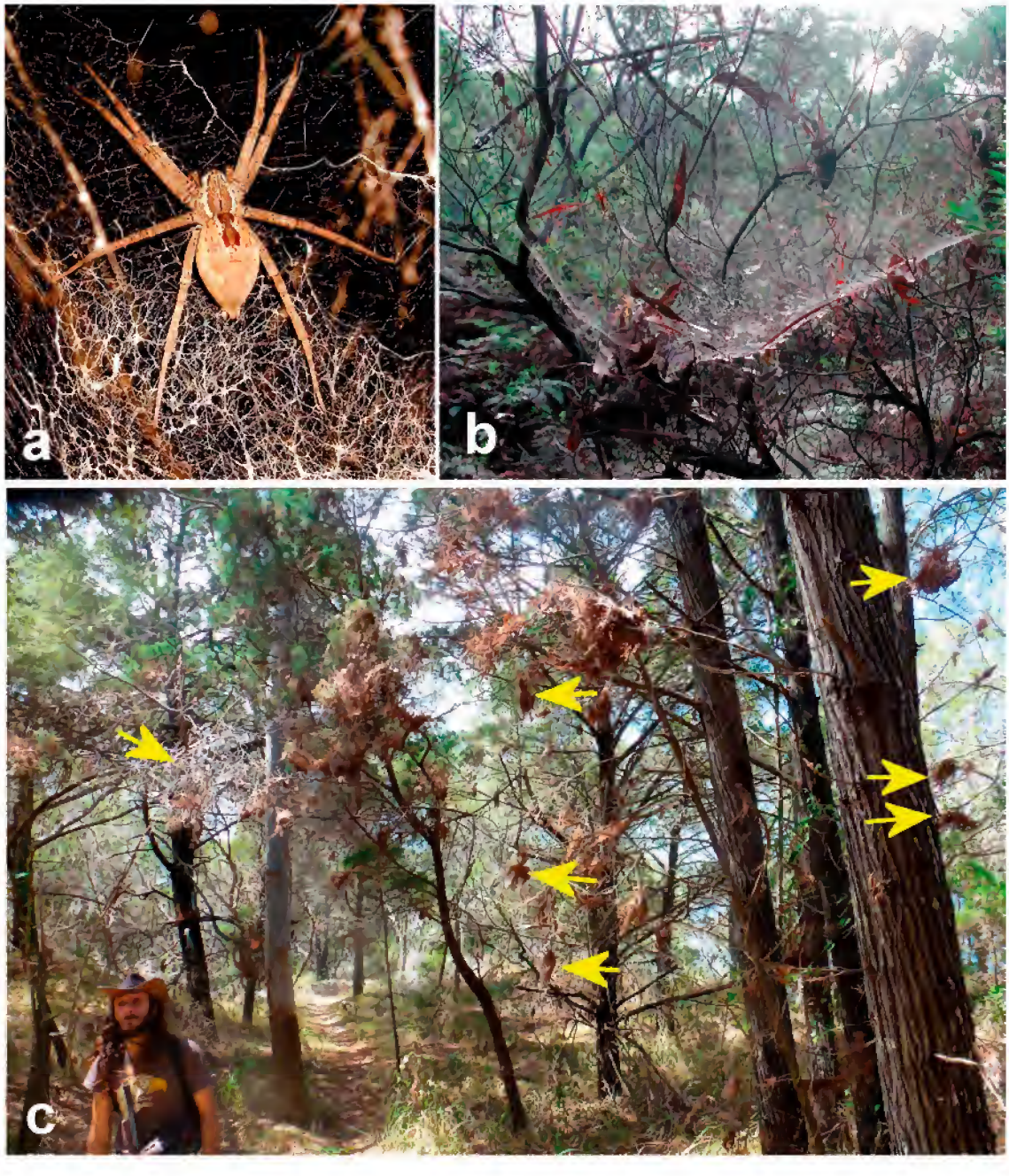


FIG. 72. *Dendrolycosa icadia* (L. Koch, 1876). **a,** habitus on web; **b,** single web showing broad agelenid-like sheet web and basal nest; **c,** forest with arrows showing nests.

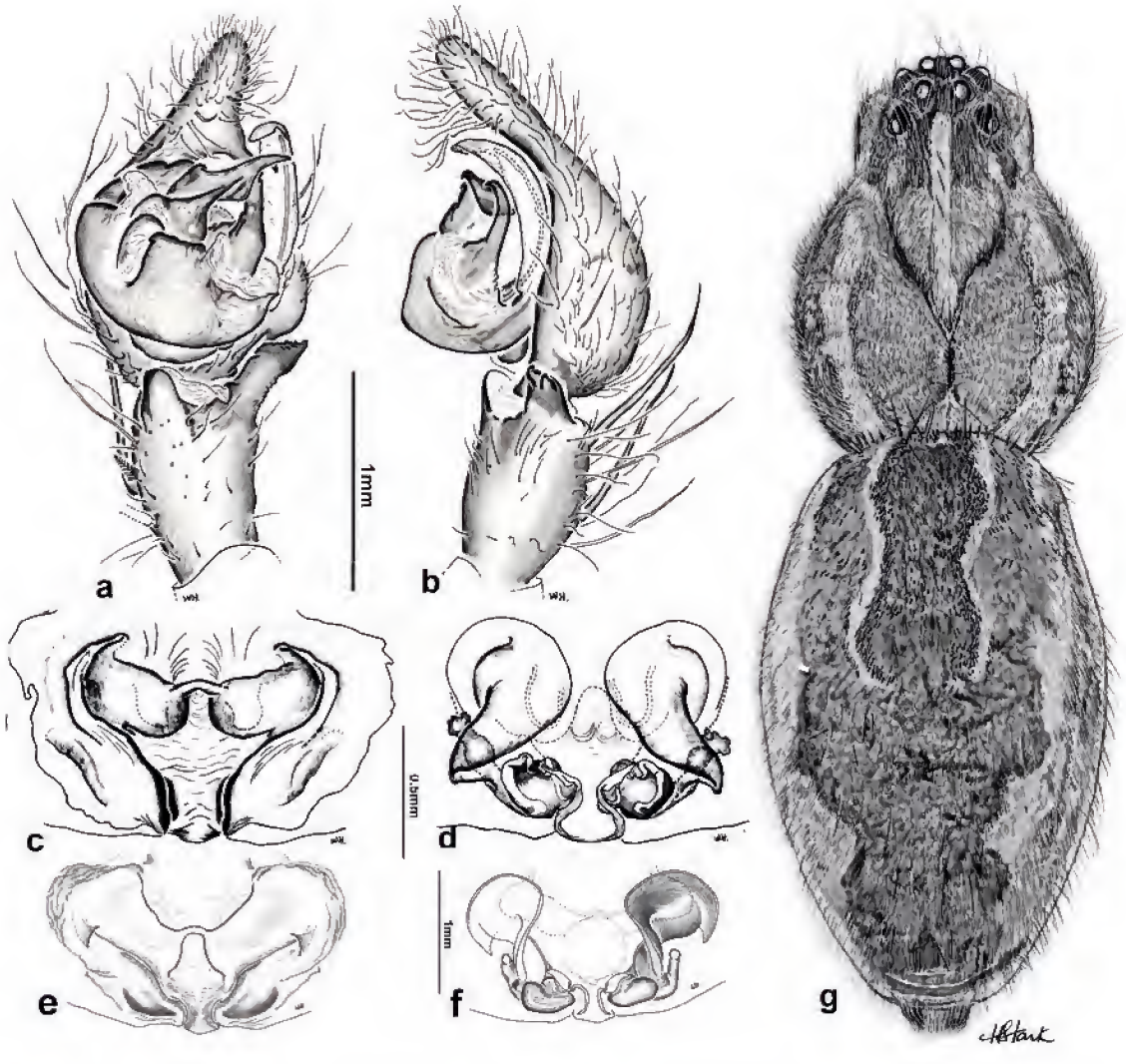


FIG. 73. *Dendrolycosa icadia* (L. Koch, 1876). **a, b,** male QM S104602, palpal patella, tibia and cymbium; **a,** ventral view; **b,** retrolateral view; **c–f,** epigyne; **c, d,** QM S80175; external (c) and internal (d) views; **e, f,** QM S12344, Torres Strait, external (e) and internal (f) views; **g,** female, habitus.

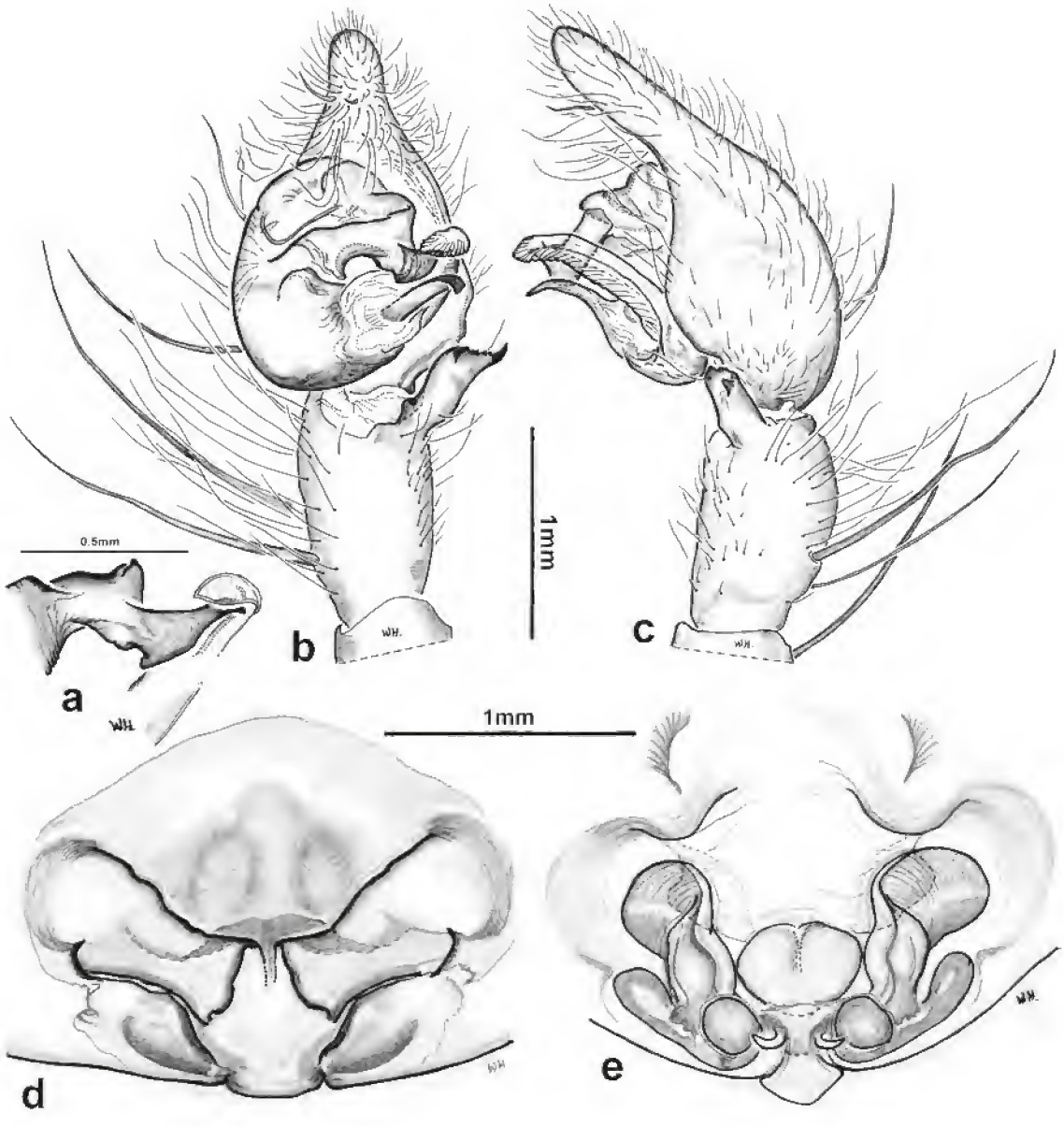


FIG. 74. *Dendrolycosa kakadu* sp. nov. **a–c,** male QM S53981, palpal patella, tibia and cymbium; **a,** apex of embolus; **b,** ventral view; **c,** retrolateral view; **d, e,** epigyne QM S53981; external (d) and internal (e) views.

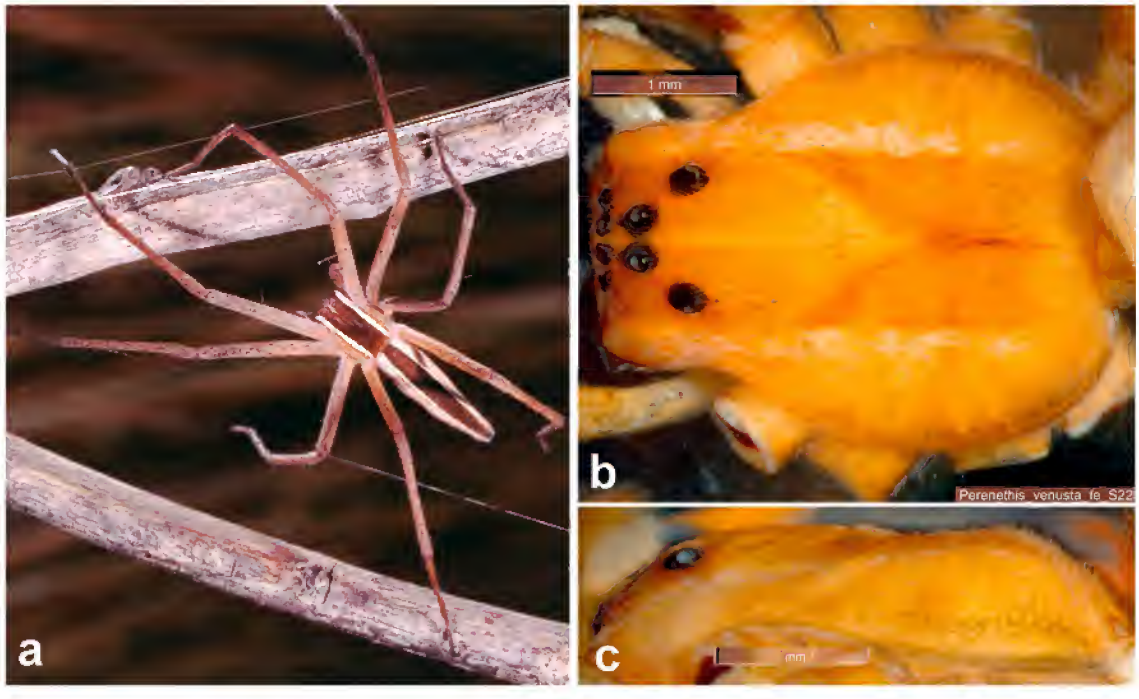


FIG. 75. *Perenethis venusta* L. Koch, 1878. **a,** female, habitus, dorsal view; image, J. Wright, QM; **b, c,** female, QM S22591, carapace; **b,** dorsal view; **c,** lateral view.

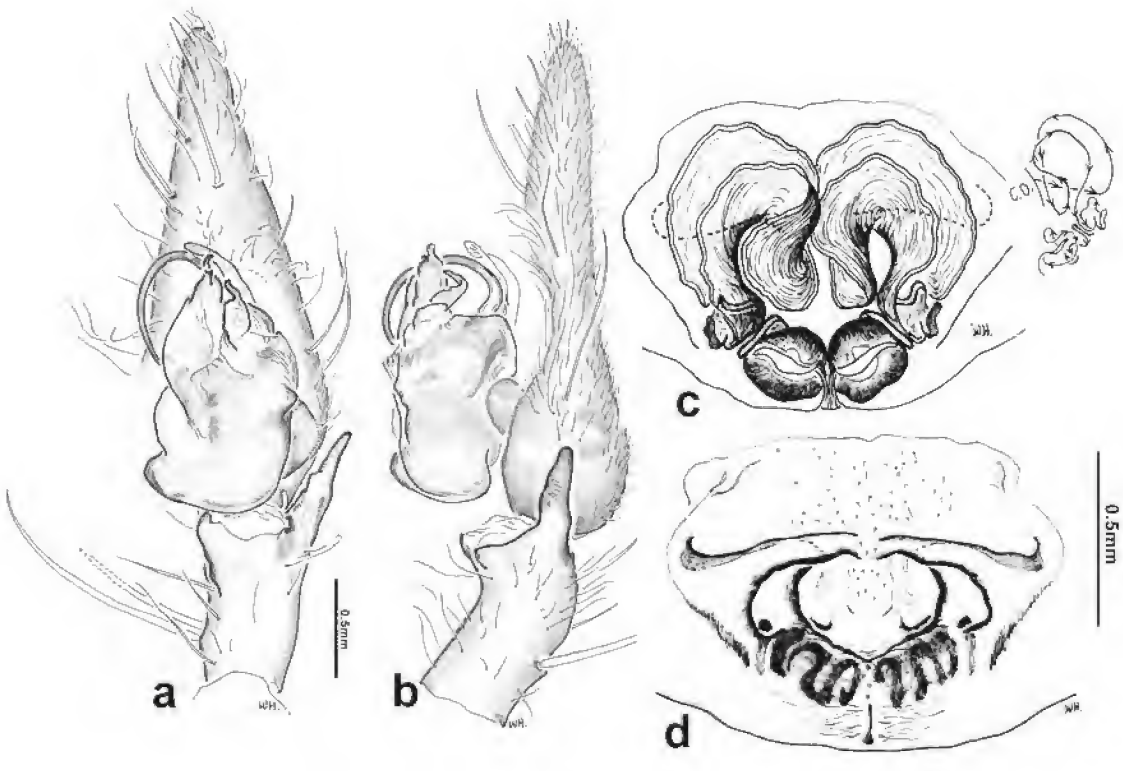


FIG. 76. *Perenethis venusta* L. Koch, 1878. **a, b**, QM S28787, male palpal patella, tibia and cymbium; **a,** ventral view; **b,** retrolateral view. **c, d,** epigyne QM S22591; external (c) and internal (d) views.

FIG. 77. *Hygropoda lineata* (Thorell, 1881), female on fine sheet, Fitzroy Island. Image, R. Raven.

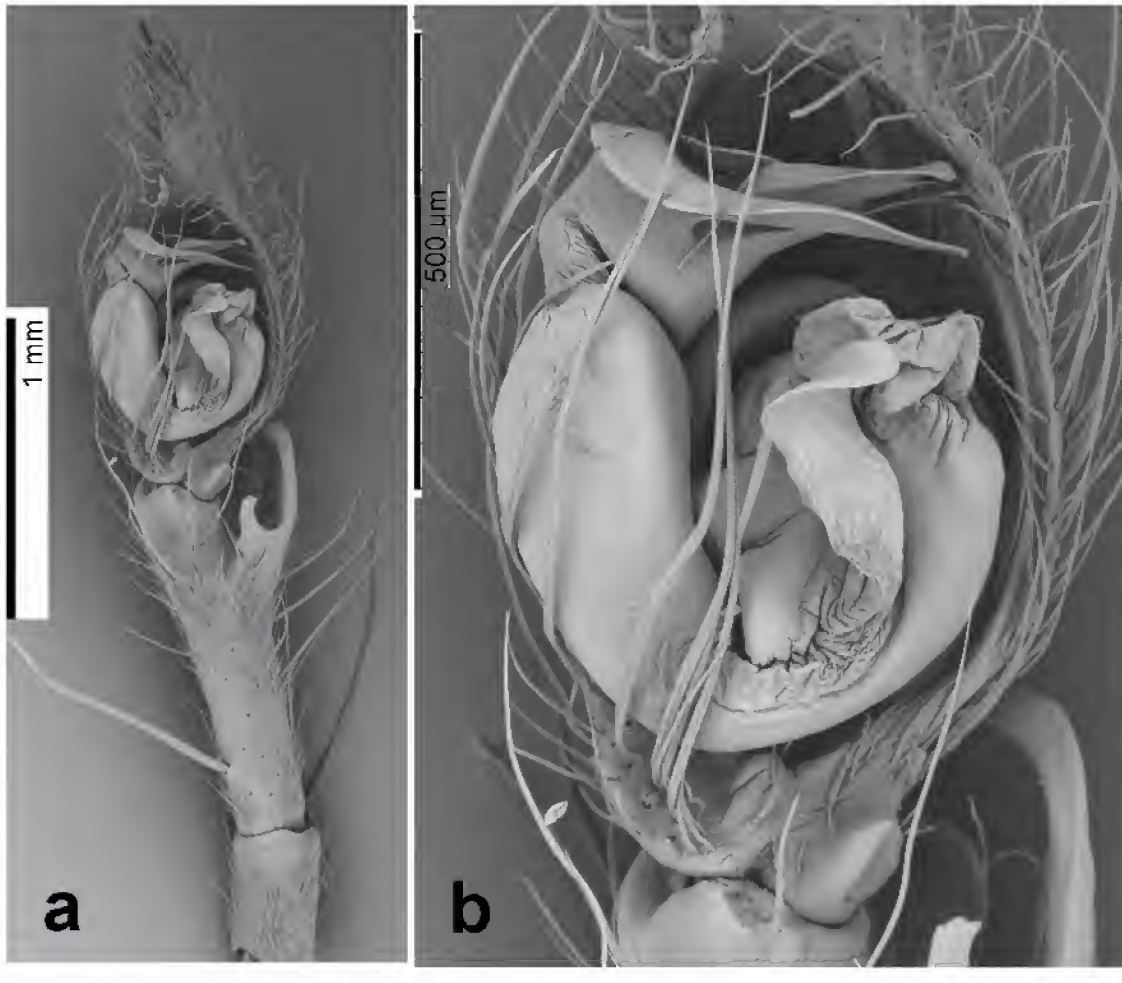


FIG. 78. *Hygropoda lineata* (Thorell, 1881), male palpal patella, tibia and cymbium, QM, Scanning electron micrographs; **a, b,** ventral view.

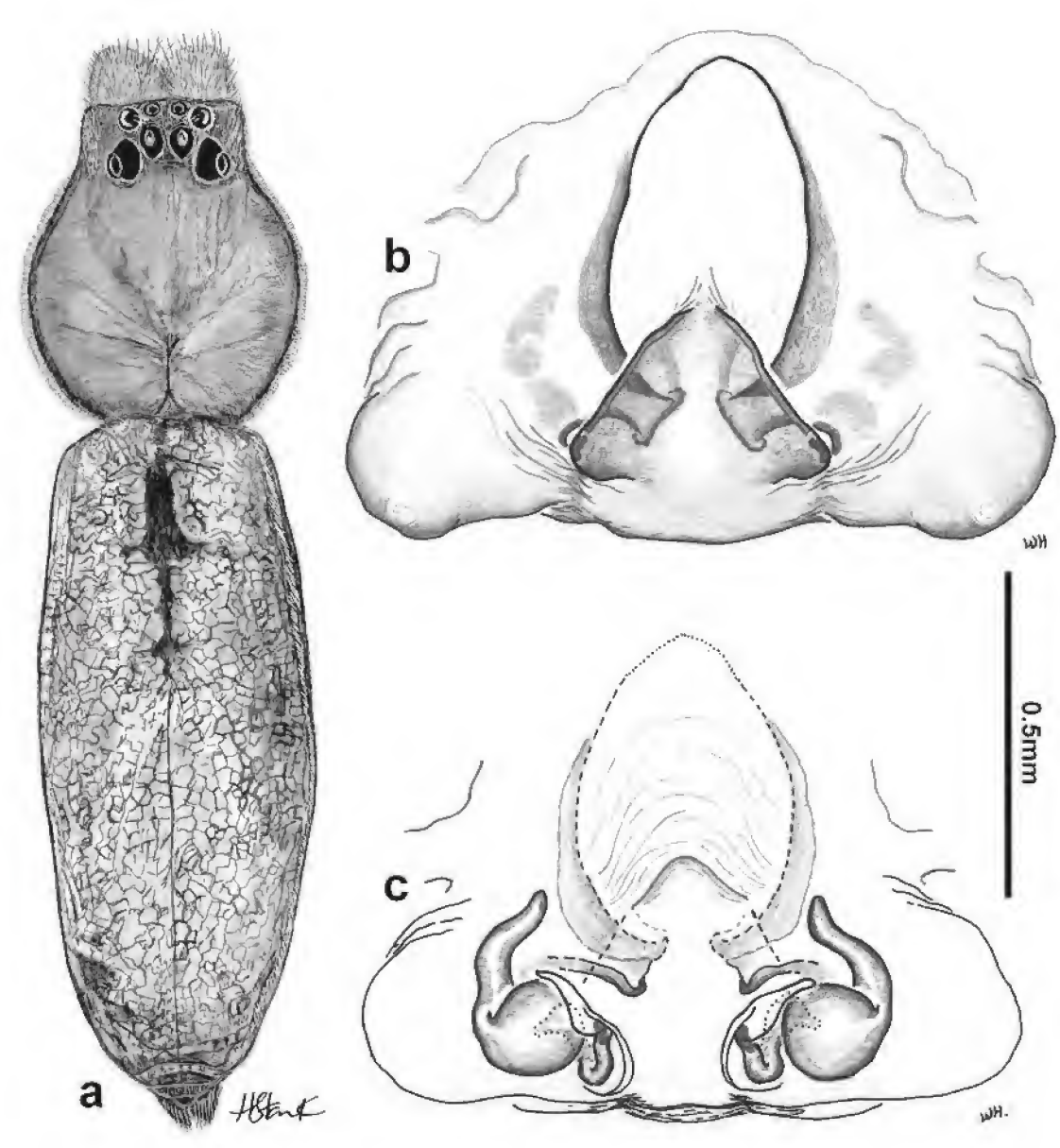


FIG. 79. *Hygropoda lineata* (Thorell, 1881), female. **a,** habitus, dorsal view; **b, c,** epigyne QM S28852; external (b) and internal (c) views.

FIG. 80. *Inola amicabilis* Davies, 1982, male QM S881. **a,** habitus, dorsal view; **b**, carapace, dorsal view; **c,** face; **d, e,** male palpal patella, tibia and cymbium; **d,** retrolateral view; **e,** ventral view.

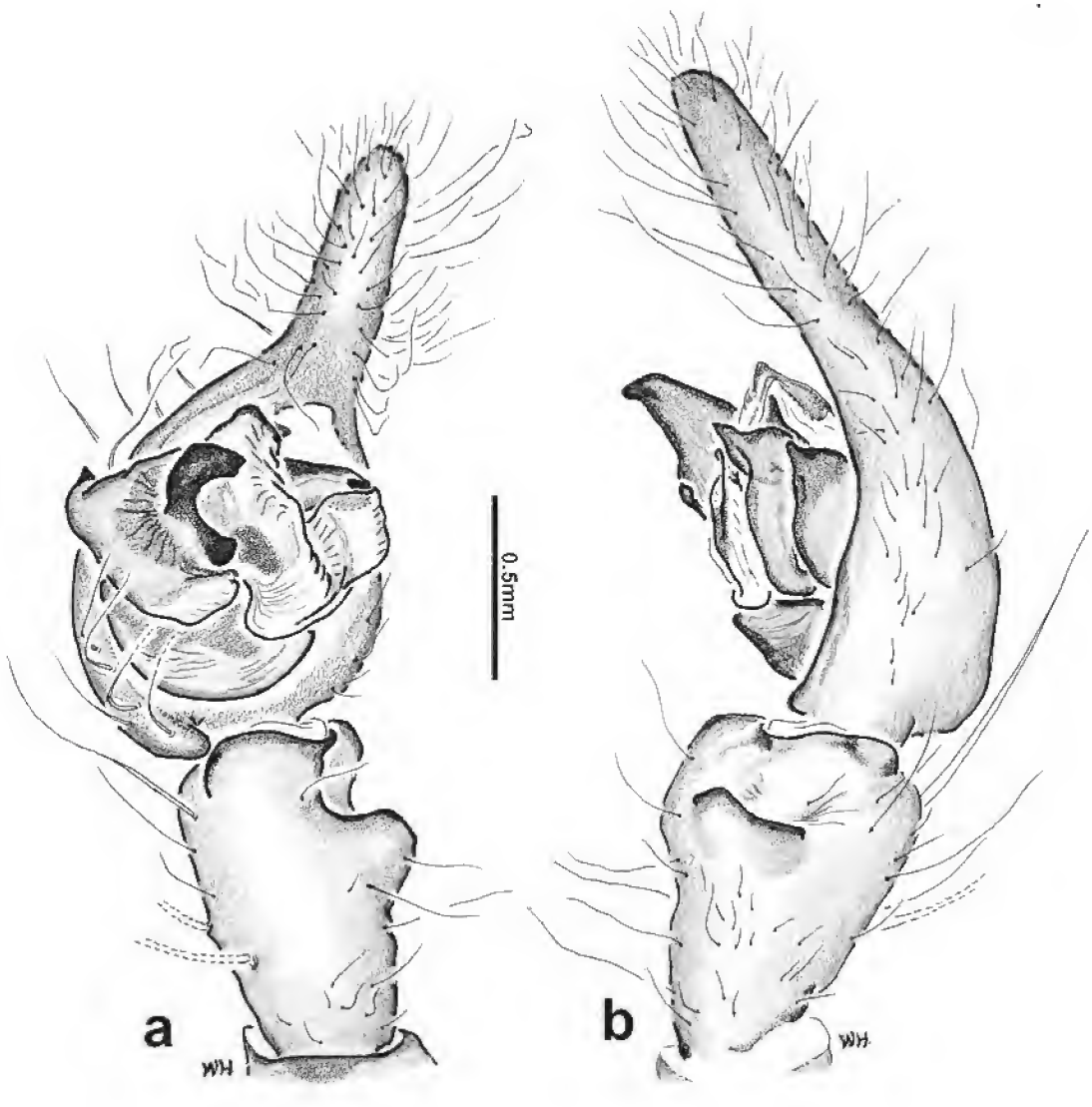


FIG. 81. *Inola amicabilis* Davies, 1982, male QM S870. **a, b,** male palpal patella, tibia and cymbium; **a,** ventral view; **b,** retrolateral view.

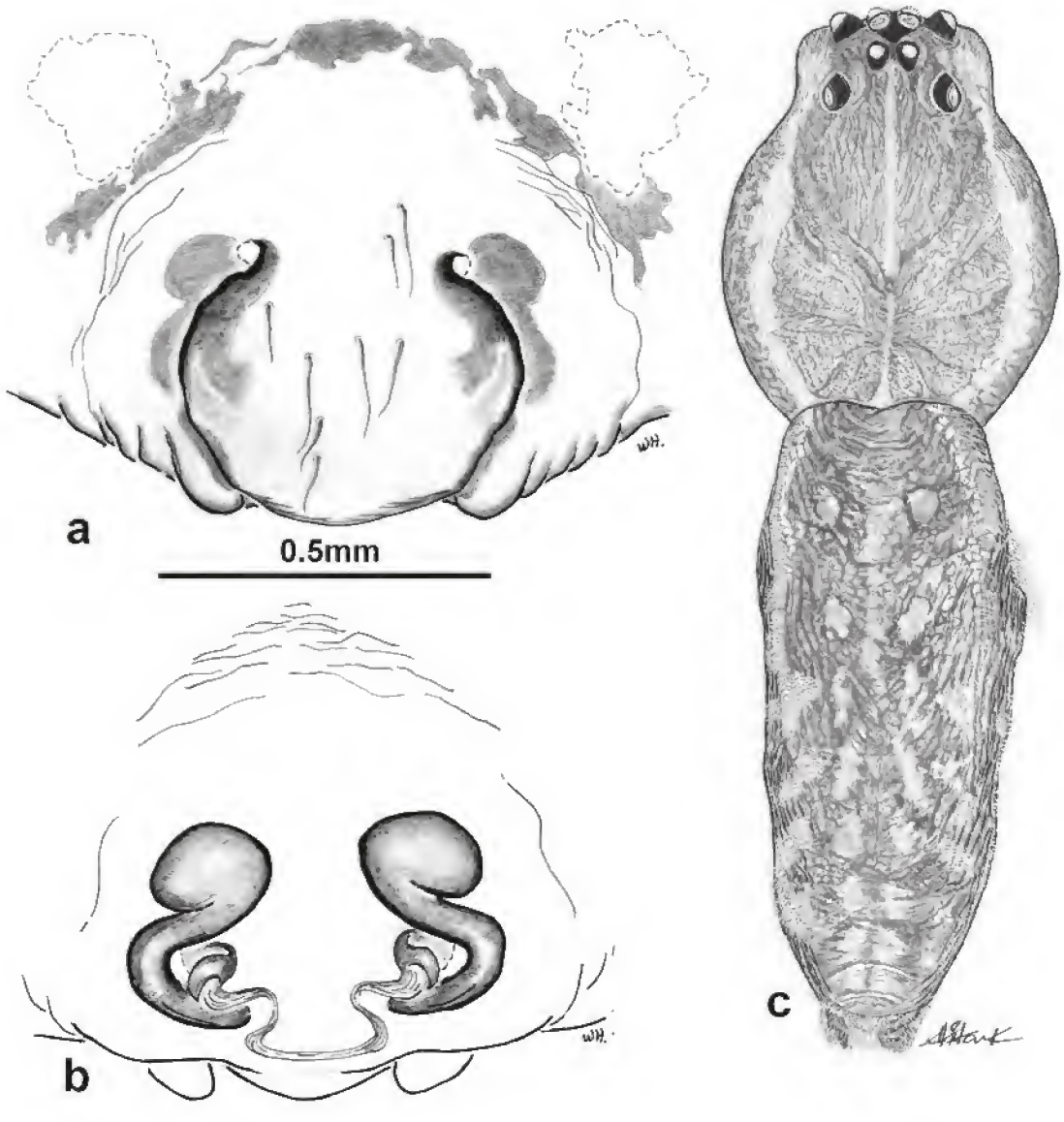
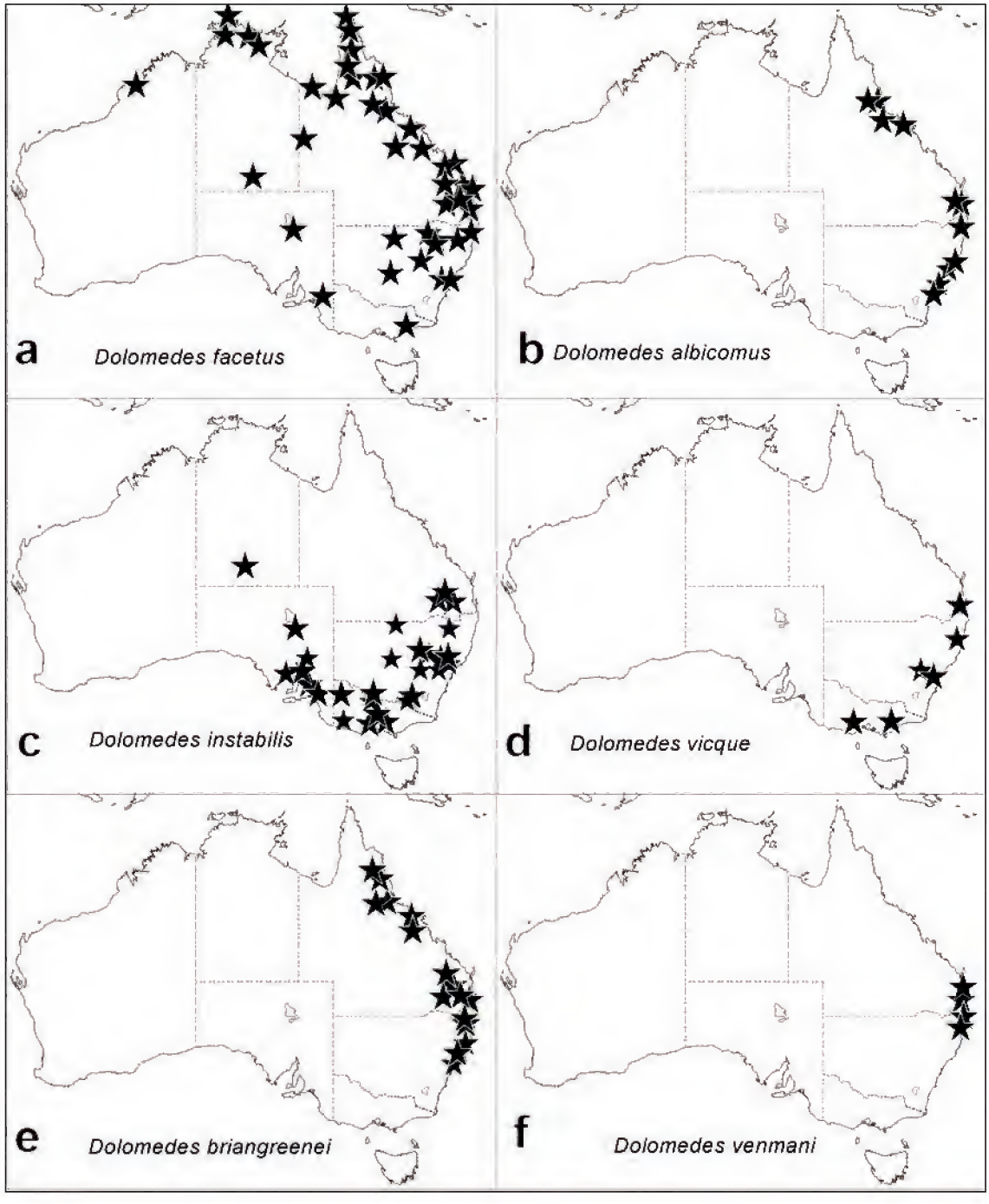
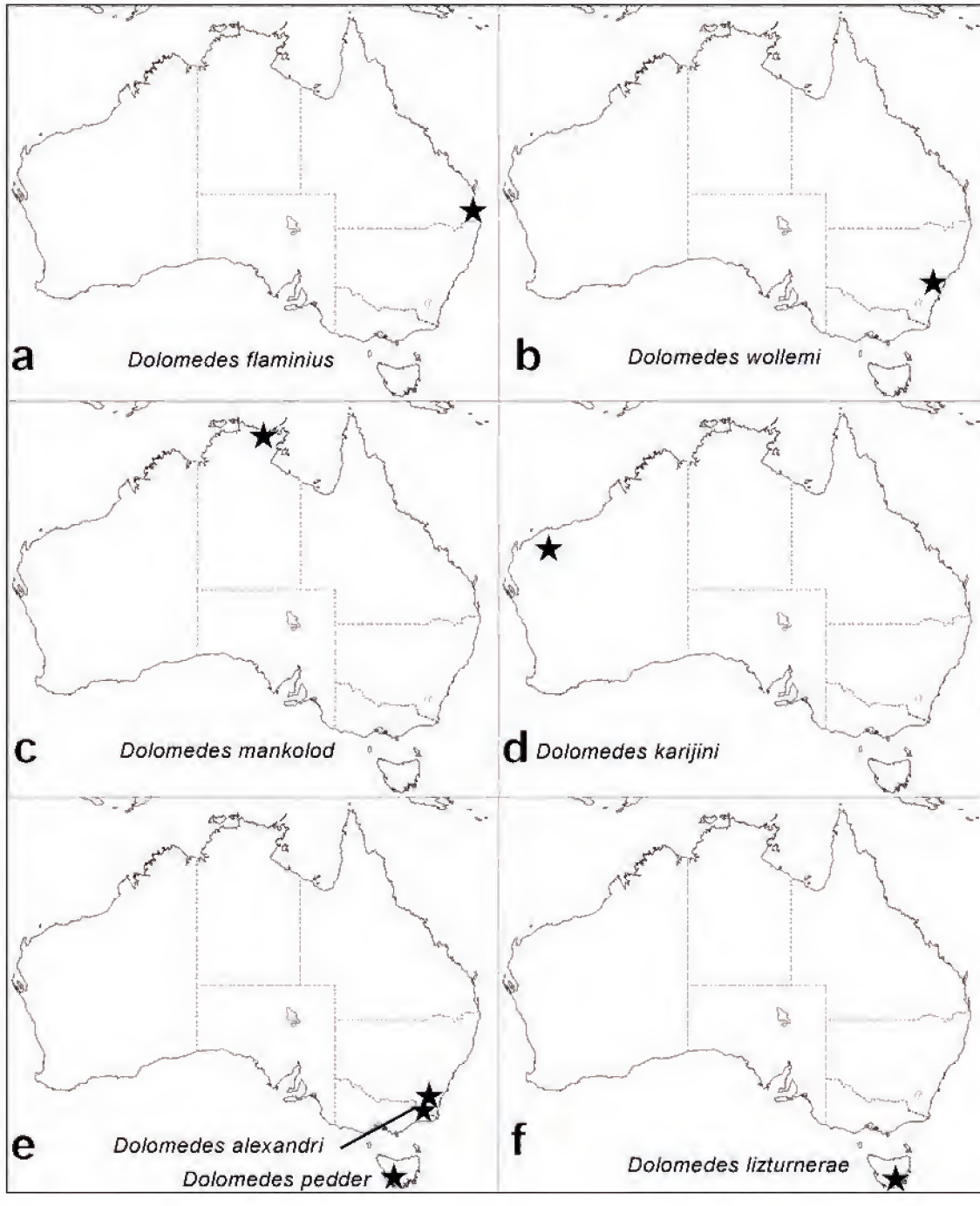


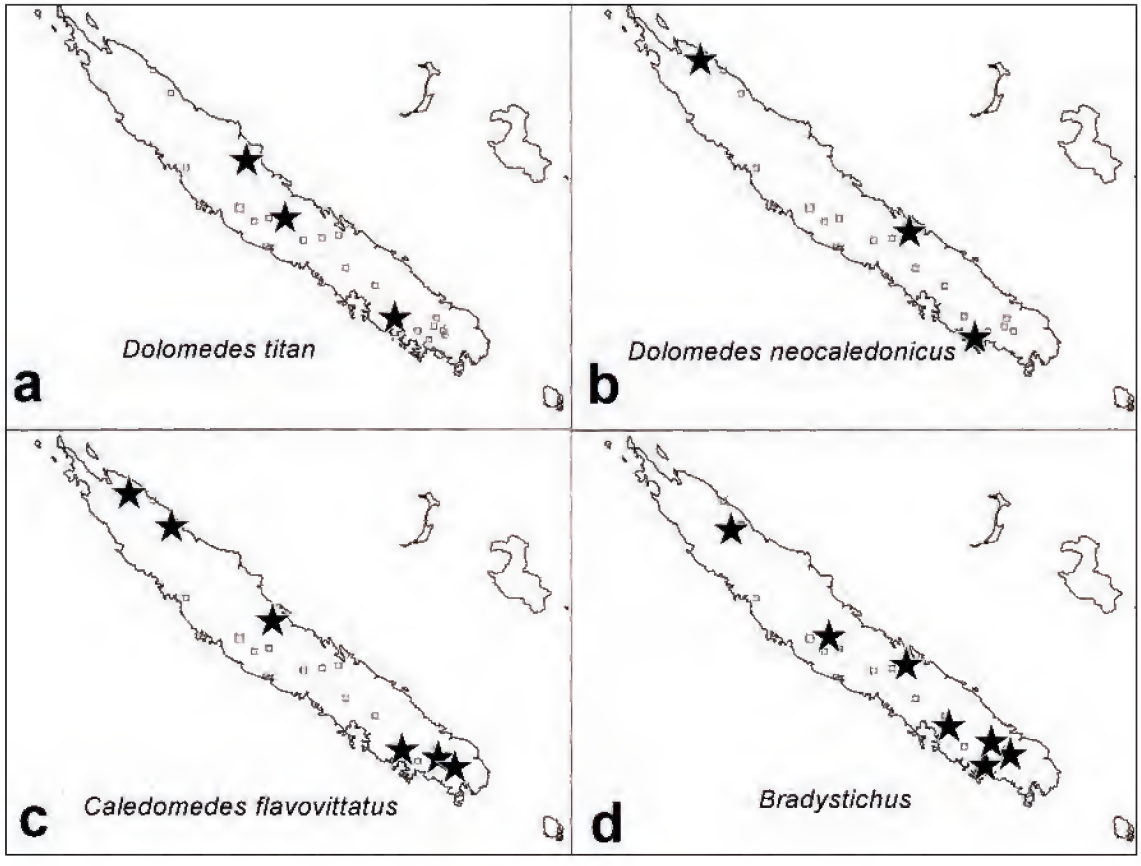
FIG. 82. *Inola amicabilis* Davies, 1982, female QM S865. **a, b**, epigyne; external (a) and internal (b) views; **c,** habitus, dorsal view.



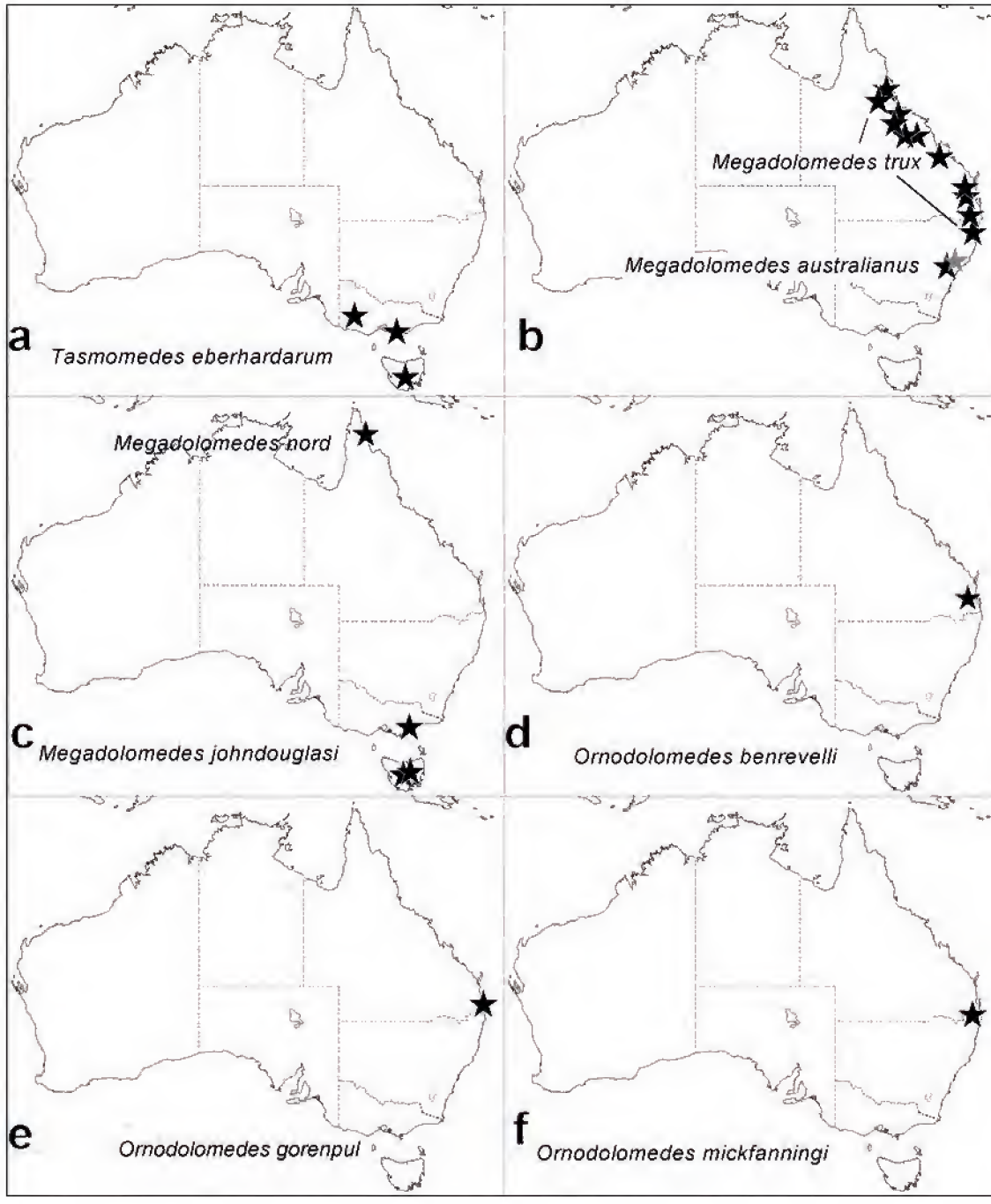
MAP 1. Records of *Dolomedes* species.



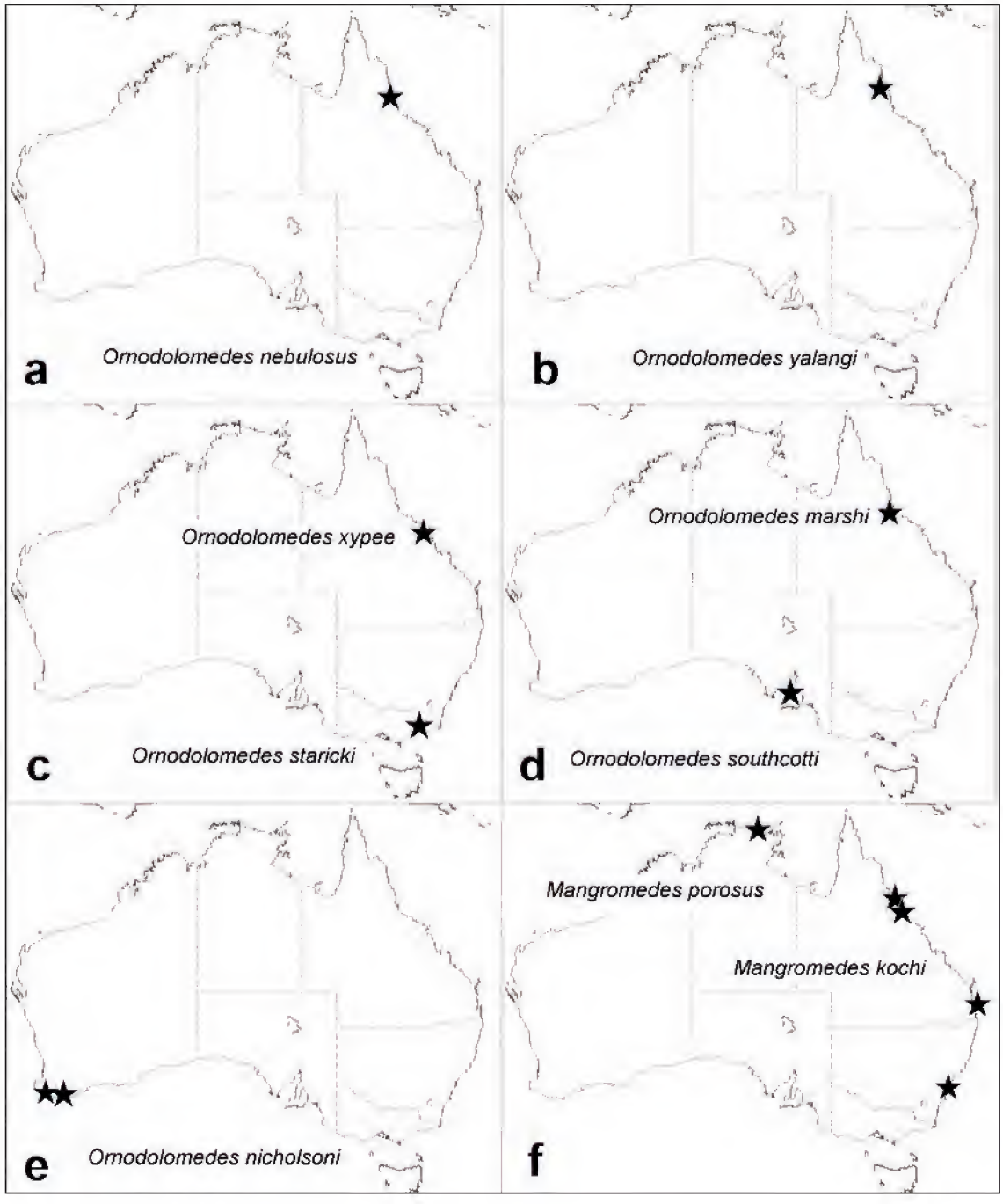
MAP 2. Records of *Dolomedes* species.



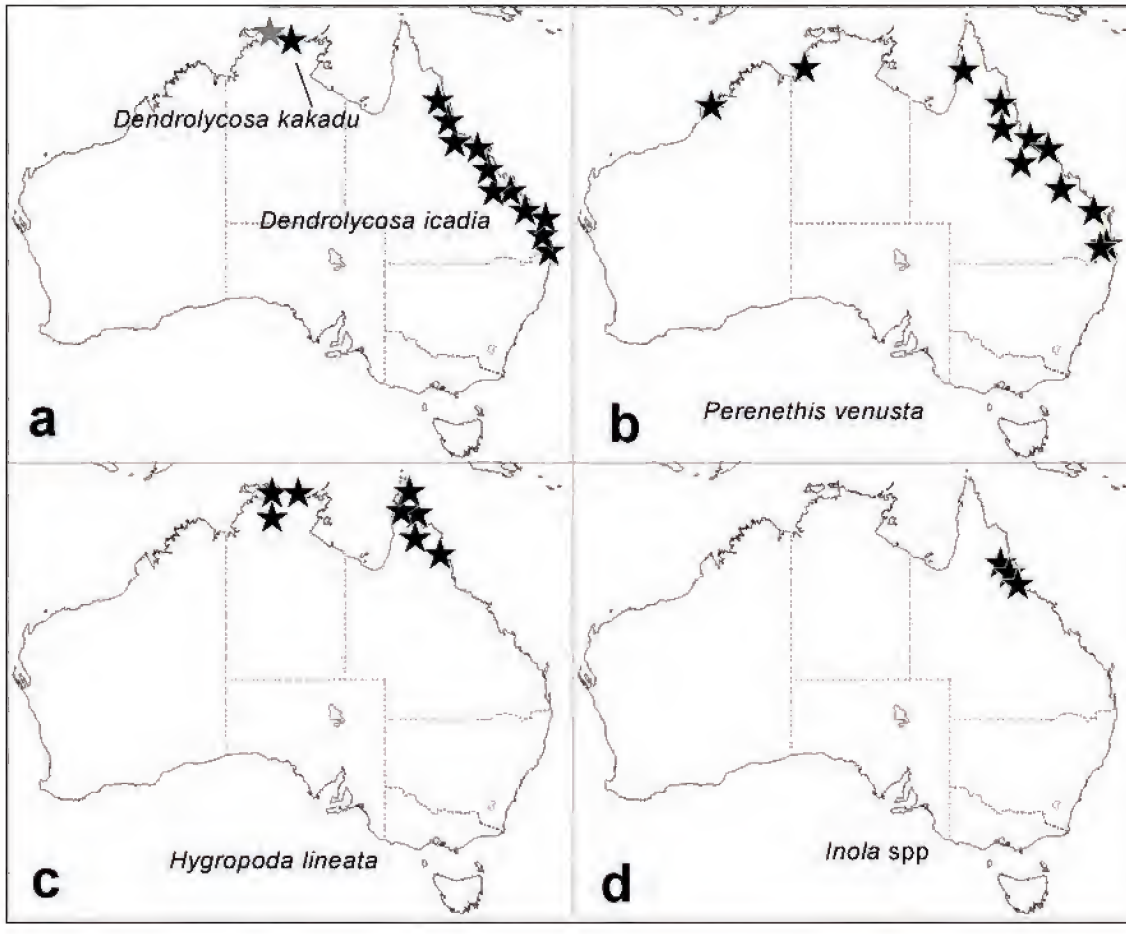
MAP 3. Records of New Caledonian Pisauridae.



MAP 4. Records of *Tasmomedes, Megadolomedes* and *Ornodolomedes*. N.B.: *Megadolomedes trux* is greyed star also.



MAP 5. Records of species of *Ornodolomedes*, gen. nov., and *Mangromedes*, gen. nov.



MAP 6. Records of species of *Dendrolycosa, Perenethis, Hygropoda* and *Inola*. N.B.: *Dendrolycosa icadia* is also a grey star.

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Morphology of the resting eggs of the Australian endemic Fairy Shrimp *Australobranchipus* (Branchiopoda: Anostraca, Branchiopodidae): similarities and differences from other anostracans.

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ABSTRACT

Eggs in large Branchiopoda are often diagnostic of species and may show some phyletic relationships. Those of the two species of *Australobranchipus* are described and are easily separable from each other and are particularly distinctive among Australian anostracans, all unrelated. Within its family, the Branchiopodidae however, there is some similarity to two African genera, but not Eurasian species, indicative perhaps of a gondwanan connection. ❐ *Australobranchipus, Branchiopoda, morphology, Fairy Shrimp.*

Australia has just three genera of fairy shrimps in freshwater, *Branchinella* Sayce, 1903, *Streptocephalus* Baird, 1852 and *Australobranchipus* and two genera of brine shrimps in saline inland waters, *Artemia* and *Parartemia* (Timms 2012). There are 40 described species of *Branchinella*, many of widespread distribution, just one of *Streptocephalus* found in the northern half of Australia and *Australobranchipus* Rogers, Timms, Jocqué and Brendonck, 2007 with two species, both in southern inland Queensland and one in the adjacent northwest New South Wales (Timms 2012). *Parartemia* Sayce, 1903 is represented by 18 species across Australia and *Artemia* Leach, 1819 by two, mainly in salt works, but with one spreading in southwest Western Australia (Timms *et al.* 2009). Each of these genera belong to different families (Artemiidae Grochowski, 1896 and Parartemiidae Daday, 1910), with *Australobranchipus* the genus of focus here, with related genera in Africa and Eurasia (Brendonck 1997).

Australobranchipus is distinct from *Branchinella*, the common genus of fairy shrimp in Australia. While the detailed structure of the gonopods is used to characterise the anostracan genera, in *Australobranhipus* easily observed almost separate frontal appendages on the male (Fig. 1) and in females the subcylindrical brood pouch are distinctive compared with fused or absent frontal appendages in male *Branchinella* and elongated brood pouch in female *Branchinella* (Rogers *et al.* 2007). Perhaps noteworthy is its small size; adult length of both species is < 10 mm (Rogers *et al.* 2007) with *A. gilgaiphila* generally near 8 mm for males and 7 mm for females (author unpublished data). Such small size is coincident with fast maturation and as far as is known *A. gilgaiphila* has the shortest time from hatching to maturity of any Australian fairy shrimp (3-4 days) and a short life cycle (ca 10 days)(author unpublished data). This gives it an advantage of not being in

FIG. 1. Image of male *Australobranchipus gilgaiphila* Rogers *et al.* 2007.

competition with larger *Branchinella* which take much longer to mature.

Differences in egg morphology are useful in distinguishing between species and species groups in many anostracans. The eggs of *Australobranchipus* have only been cursorily described but seem to be different from those of *Branchinella* and *Streptocephalus* but with affinities to some African branchiopodids. I report in detail on the eggs of both known species, and to compare their morphology with those of other branchiopodids and with eggs of other Australian genera.

MATERIALS AND METHODS

Mature resting eggs were removed from the brood pouches of preserved females, air-dried and the mounted on carbon tabs on aluminium stubs and gold splutter coated. Ten per collection were photographed on a Zeiss Evo LS15 SEM using a Robinson Backscatter Detector. An average egg diameter was determined for each egg and the characteristic ridges and depressions noted. These were counted on the visible side (whole ridges/ depressions plus some only partly visible and scored as ½) then doubled to obtain the total number per egg.

RESULTS

Australobranchipus parooensis Rogers *et al.*, 2007 (Fig. 2A, B, C)

Eggs were studied from the paratypes (AM P67198) which came from the type locality (Marsilea Pond (29° 32′ 13.4″S, 144°52′ 26.0″E), Bloodwood Station, 130 km nw of Bourke, New South Wales, 5 August 1998, B.V. Timms).

Egg irregularly cylindrical, length 225-238 µm, diameter 196-210 µm, n=10. Cylinder with 9-12 vertical ridges and 8-11 intervening rectangular depressions. Depression floors sloping laterally but flatish centrally with enclosing ridges narrow (5-15 µm) and rounded marginally. End ridges extended so that cylinder ends flanged; ends with 1-4 irregularly shaped cells, each U-shaped and marginal ridges flanged. Egg surface everywhere with innumerable microdepressions, extremely small (<2 µm) on depression floors morphing gradually into larger depressions (ca. 6 µm) ridge margins. The depressions with thick rounded walls and flat floors. Ridge margins thus an uneven mix of depressions and their margins. A few small spherical lumps (ca. 6 µm) superficially on and around the depressions. Eggs often seen grouped together (see Fig 11 in Timms *et al.* 2003), with the flanges interlocked.

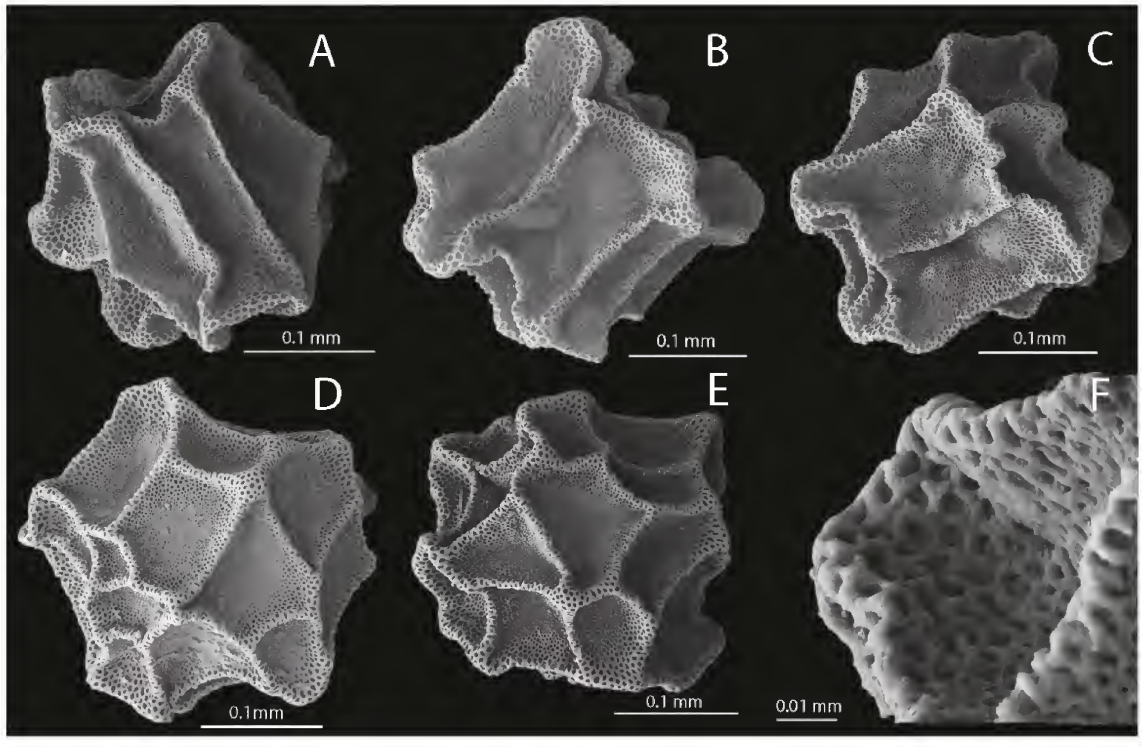

FIG. 2. Scanning Electron Micrographs of the eggs of *Australobranchipus parooensis* Rogers *et al.* 2007 (A, B, C) and *A. gilgaiphila* Rogers *et al.*2007 (D, E, F).

Australobranchipus gilgaiphila
Rogers *et al.*, 2007
(Fig. 2D, E, F)

Eggs were studied from females collected from a pool 25 km west of Bollon besides the Bolonne Highway (28° 01'S, 147° 03'E), Queensland, 26 June 2005, B.V. Timms, QM W27983.

Egg irregularly spherical, diameter 248-265 µm, n = 10. Egg surface divided into 24-32 polygonal depressions of various sizes with length and width subequal, each flatish floored with narrow dividing ridges (5-15 µm) with rounded margins. Egg surface covered with innumerable microdepressions, extremely small (< 2 µm) on depression floors morphing gradually into larger depressions (ca. 6 µm) ridge margins.Microdepressions with thick rounded walls and flat floors (Fig 2F). Numerous small (ca. 1-2 µm) spherical protrusions on the walls and floors of the depressions. Eggs also often grouped in the brood chamber but not to the same extent as in *A. parooensis*.

DISCUSSION

There are six genera in the Branchiopodidae (Rogers 2013), and although there is some overlap in egg morphology between some genera, the morphology of the eggs of *Australobranchipus* is distinctive. The normal morphology in *Branchipus* (Mura 1986) and *Branchipodopsis* (Hamer & Appleton 1996; Van Damme *et al.* 2004; Thiéry & Jean 2004) is spherical eggs with surficial polygonal depressions. These depressions differ between species somewhat in numbers, depth and intervening ridge structure so that the eggs of many species are distinctive within each genus. One of the greatest departures from this model, is seen in *Branchipus cortesi* Alonso & Jaume where the eggs are irregularly spherical and some ridges between depressions are flared

(Alonso & Jaume 1991), reminiscent of the structure in *Australobranchipus* eggs. However *B. cortesi* eggs lack the mircodepressions of *Australobranchipus* eggs. Another genus with spherical eggs is *Pumilibranchipus* from Namibia in Africa (Hamer & Brendonck 1995). Its eggs lack polygonal depressions but are completely covered with surface depressions superficially like those in *Australobranchipus*. However *Pumilibranchipus* depressions are larger (ca. 10-17 µm) and appear to be curved in cross section as opposed to flat in *Australobranchipus* (Hamer & Brendonck 1995 Figs 12 & 13).The remaining two genera, *Metabranchipus* and *Rhinobranchipus*, both African, have irregularly shaped eggs with just a few deep polygonal depressions (Brendonck 1995; Rogers & Hamer 2012). In this they resemble eggs of *A. gilgaiphila*, but again the microdepressions on the ridges in *Australobranchipus* are distinctive. It is of interest that the eggs of *Australobranchipus* are most similar to African genera rather than the European based *Branchipus* and African/ Asian *Branchipodopsis* which may suggest a gondwanan relationship.

Egg structure is only weakly phyletic (cf eggs of Artemiina vs Anostracina; Limnadiidae vs Cyzicidae vs Laevicaudata vs Notostraca), partly because of specific adaptations to environmental needs. This may be to counter predation (Dumont *et al.*, 2002); in the case of *Australobranchipus* the prominent ridges and flanges may deter predation just as in *Branchinella longirostris* the numerous spines and hooks counter attack by flatworms (Timms & Lindsay 2011). On the other hand the ridges and flanges tend to lock eggs together in multiunit masses. This feature intuitively could lessen dispersal opportunities, though Pinceel *et al.* 2015 suggest this may not be so, and experimentation using egg masses and individual eggs are needed. Each species has a narrow distribution of a few hundred km^2, suggesting dispersal limitations, but equally this may be due to the limited geographical spread of the specific habitat in which each lives. Egg morphology is not random, but finding the meaning is difficult.

The eggs of *Australobranchipus* are also distinctive among eggs of other Australian anostracans. Eggs of introduced *Artemia* (2 forms) and most native *Parartemia* (12 of the 18 species so far examined) are spherical and without surface adornment (Timms *et al.* 2003; Timms & Hudson 2009; author, unpublished data); the remainder have yet to be studied, but are not expected to be too different. Eggs of the single species of *Streptocephalus* (*S. archeri* Sars) are distinctive, being tetrahedral in shape with four triangular faces (Timms, *et al.* 2003) as it typical for the subgenus *Parastreptocephalus* (Brendonck & Coomans 1994a, 1994b). The 40 species of *Branchinella* known at present all have spherical eggs with polygonal depressions (Timms 2015; Timms & Lindsay 2011; author, unpub. data). These vary in size, complexity, compartment numbers and adornment, but none are like the eggs of *Australobranchipus*. Three features of *Australobranchipus* eggs are distinctive: (a) the non-spherical shape, (b) the numerous microdepressions particularly on the ridge margins which give it a praetextate appearance (= a Roman garment weaved with a fringe of hollows and ridges), and (c) the interlocking of the ridges/flanks so that individual eggs tend to mass together.

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